Research Report

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AI ON THE GROUND:

A SNAPSHOT OF AI USE IN INDIA

TANDEM RESEARCH

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Authors

Urvashi Aneja, Vikrom Mathur, Angelina Chamuah, Abishek Reddy, Harsh Ghildiyal & Joanne D'Cunha

With inputs from

Natalia Sanchez Kumar and Anushree Gupta

Design

LMNO Design (www.lmno.in), Chandika Gupta

Copy-editor

Rajyashree Dutt

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Tandem Research

hello@tandemresearch.org

343 Coimavaddo Quitla, Aldona, Bardez - 403508, Goa, India.

www.tandemresearch.org

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ABBREVIATIONS

AASMA
Advanced Application for Social Media Analytics

ABHED
Artificial Intelligence Based Human Efface Detection

AI
Artificial Intelligence

AIoT
The Artificial Intelligence of Things

AWS
Amazon Web Services

BBMP
Bruhat Bengaluru Mahanagara Palike

BFSI
Banking and Financial Services

Bn
Billion

BOD
Biological oxygen demand

BPRD
Bureau of Police Research and Development

BSE
Bombay Stock Exchange

CAGR
Compound annual growth rate

CAIR
Centre for Artificial Intelligence and Robotics

CBSE
Central Board of Secondary Education

CERT-In
Indian - Computer Emergency Response Team

CSCs
Common Service Centers

CCTNS
Crime and Criminal Tracking Network and Systems

CCTV
Closed-circuit television

CMAPS
Crime Mapping, Analytics and Predictive System

CPWD
Central Public Works Department

CRM
Customer Relationship Management

CT scan
A computerized tomography scan

COD
Chemical oxygen demand

DO
Dissolved oxygen

EdTech
Education Technology

ERP
Enterprise Resource Planning

EHR
Electronic Health Record

eNAM
National Agricultural Market

EY
Ernst & Young Global Limited

FICCI
The Federation of Indian Chambers of Commerce & Industry

GDPR
General Data Protection Regulation

GPS
Global Positioning System

HCG
Healthcare Global Enterprises Ltd

ICRIER
Indian Council for Research on International Economic Relations

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics

ICT
Information and Communication Technology

ICTAI
International Centre for Transformational Artificial Intelligence

IDRBT
Institute for Development and Research in Banking Technology

IFFCO
Indian Farmers Fertiliser Cooperative

IIIT
International Institute of Information Technology

IMD
India Meteorological Department

IoT
The Internet of Things

IRCTC
Indian Railway Catering and Tourism Corporation

IRDA
Insurance Regulatory and Development Authority

ABBREVIATIONS

ISRO
Indian Space Research Organisation

JARVIS
Joint AI Research for Video Instances and Streams

K12
Education from Kindergarten to the 12th Standard (primary & secondary)

KCC
Kisan Credit Card

KPMG
KPMG International Cooperative (a multinational professional services network)

KYC
Know Your Customer

MDR
Medical Devices Rules

MEITY
Ministry of Electronics and Information Technology, Government of India

ML
Machine learning

MoHUA
Ministry of Housing and Urban Affairs

MOOC
Massive Open Online Courses

MoU
Memorandum of Understanding

NAIM
National artificial intelligence marketplace

NASSCOM
The National Association of Software and Service Companies

NATGRID
National intelligence grid

NCRB National
Crime Records Bureau

NDHM
National Digital Health Mission

NHA
National Health Authority

NHS
National Health Stack

NITI Aayog
The National Institution for Transforming India

NLP
Natural Language Processing

NLP
Neuro-Linguistic Programming

NSSO
National Sample Survey Office, Ministry of Statistics and Programme Implementation, Government of India

OCR
Optical Character Reader

OCR
Optical Character Recognition

PAIS
Punjab Artificial Intelligence System

P2P
Person to person

pH
Potential of Hydrogen. It is a measure of how acidic/ basic water is

PM-JAY
Pradhan Mantri Jan Arogya Yojana

PWC
PricewaterhouseCoopers

RBA
Robotic process automation

RBI
Reserve Bank of India

RNTCP
Revised National Tuberculosis Control Program

RPF
Railway Protection Force

RTDAI
Real Time Digital Authentication of Identity

RTI
Right to Information Act

SAS
Statistical Analysis System

SEBI
Securities Exchange Board of India

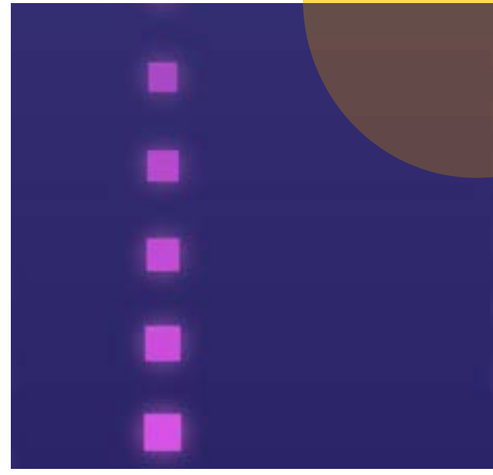
SEIMANS
Smart Environment Information and Management System

Smart PV Solution
Smart photovoltaic solution

TPDDL
Tata Power Delhi Distribution

TS
Total solids

VC
Venture Capital



Executive Summary

The spread of Artificial Intelligence (AI) could radically transform society - affecting how we live, communicate, govern, and work. Governments and businesses across the globe are highlighting the enormous potential of AI, and amping up their investments in its development and deployment. Even as AI is poised to deliver unprecedented benefits to society, the use of it in everyday life presents potential harms that are equally challenging. There is a pressing need for greater public debate and scrutiny on the potential benefits and harms that the use of AI presents.

In India, under the brand of AI for All, the government has launched several efforts to catalyse and develop the AI ecosystem, particularly in key sectors such as agriculture, education and healthcare. But the development of AI, if unregulated, will give rise to complex challenges and harm, around issues such as accountability, discrimination, and misuse. What India, therefore, needs urgently are technology and regulatory policies that embrace innovation and enable the production of economic value, but concomitantly address the societal harms that AI innovations can engender.

The debate around AI in India has become polarised - while advocates present it as a panacea for solving India's persistent developmental challenges, detractors highlight the threats to liberty, rights, and equal opportunity that AI technologies can give rise to. There is currently a lack of extensive and grounded research in India on the actual uses of AI in order to inform policy. While new opportunities and harms related to AI are announced in the media almost daily, there is a need for research grounded in the country's unique context in order to identify the key issues related to AI development and deployment in India.

This report aims to provide a snapshot of India's AI ecosystem, by examining the existing AI-based products and services across 9 key sectors. It identifies 70+ types of AI use across these sectors, and provides an overview of possible benefits, challenges to adoption, and potential harms across these sectors. Based on this analysis, the report presents key policy pathways for AI in India that can shape societal trajectories of AI towards an equitable, safe, and just technological future.

Overleaf, we present a summary of AI use, benefits and harms across 9 sectors and a set of policy recommendations to address associated harms.

Summary Table: Uses, Benefits, and Harm

SECTOR	WHAT IS AI USED FOR?	POTENTIAL BENEFITS	POTENTIAL HARM
Agriculture	• Precision farming and agribots • Farm-to-Market supply chains • Financial solutions for farmers	• Improve farm-level productivity and farmer income • Reduce resource consumption and wastage of produce across supply chain • Provide personalised financial solutions to farmers	• Domination of AI-based Agritech market by large companies • Crop failure or losses for farmers due to incorrect advice • Job losses from automation, especially for women
Banking, Financial Services and Insurance	• Onboarding new (under-banked / unbanked) customers • Customer experience and service delivery optimisation • Internal efficiency optimisation	• Support financial inclusion • Increase customer loyalty and retention rates for banks and financial institutions • Improve internal efficiency and turnaround time for processing claims, and cut down financial losses.	• Threat to privacy due to high volume of granular data collection • Discriminatory outcomes and undetected biases in proprietary systems • Financial identity fraud and cyberattacks on financial information • Job losses from automation of customer service reps, investment managers

Education	• Personalised and adaptive learning • Remote proctoring • School and institutional management • NLP for language skill development • Career counselling • Education loan underwriting	• Provide personalised learning and career progression pathways for students • Reduce administrative duties for teachers • Compensate shortage in qualified teachers • Remove linguistic barriers to educational content	• Reduce the role of the teacher • Widen existing disparities in access to quality education • Threat to privacy and agency of children • Reproduce bias and discrimination against marginalised groups
Energy and Water	• Optimising consumption and generation • Resource monitoring	• Efficient calibration of demand and supply • Optimise energy consumption and water quality management • Cut losses from energy theft, equipment failure • Improve cybersecurity vigilance	• Intrusive monitoring and profiling of households and people • Cybersecurity attacks on critical infrastructure
Enterprise Solutions	• Data-driven business intelligence • Customer engagement services • Process and task optimisation and automation • Tareted advertising and content marketing	• Increase internal efficiency of enterprises • Business growth and productivity • Enable personalisation of products and services • Improve products and services discovery for consumers	• Market monopolisation by larger AI-ready companies • Intrusive consumer behaviour profiling and manipulation • Job loss, particularly for entry level tasks • Cyberattacks and data breaches
Healthcare	• Disease detection and forecasting • Personalised healthcare • Remote health monitoring • Back-end Process Optimisation • Medical R&D and training • Assistive surgery	• Provide early detection of diseases and reduce diagnosis time Reduce hospital administration burden • Improve efficacy of treatments through personalised plans • Augment research for medical breakthroughs and assist in drug discovery	• Misdiagnosis resulting in health complications • Reproduce patterns of inequitable access • Misuse of health data by insurance companies • Erosion of health data privacy and behavioural surveillance

Policing	• Real-time monitoring and crime detection • Deterrence and preemptive policing • Internal efficiency management and checks • Public-facing police interventions	• Augment police capacity • Reduce workload of police personnel • Increase efficiency in crime investigations • Enable proactive police measures	• Undermine constitutionally guaranteed rights and liberties • Wrongful prosecution and over-policing of marginalised groups • Erosion of individual privacy and growth of mass surveillance capacities • Cybersecurity attacks on digital police infrastructure
Public Tech	• Citizen engagement • Optimisation of public service delivery	• Increase political and civic participation • Improve service delivery and access to information • Improve citizen experience of government services	• Threat to privacy and security due to centralisation of databases • Reduce agency and accountability of government employees • Inability to contest algorithmic decisions due to lack of explainability and transparency • Exclusion of already digitally excluded and marginalised groups
Workplace	• Task optimisation and automation • Employee monitoring and engagement • Streamline hiring practices	• Enhance efficiency, increase productivity, and optimise workflows • Reduce workload, assist in making better decisions and provide timely feedback • Avoid or reduce exposure to dangerous tasks	• Reduce worker agency and self-determination capacity • Intrusive workplace surveillance and behaviour management • Job loss and increased precarity of platform and gig workers, informal workers • Reproduce existing social biases against gender, caste and class

Our Learnings

- Small but incremental benefits are accruing from the deployment of AI and ML-enabled systems.
- Narratives of the transformative impacts of AI are yet to be matched by current use cases.
- It is not simply the technology, but its use that also requires closer public scrutiny.
- Many development and deployment challenges are similar across sectors.
- Greater oversight is needed when Machine Learning (ML) applications are central to decision- making about people, their rights, livelihoods, and relationships.
- ML systems that enable the profiling of individuals and groups require adequate checks and balances.
- The use of AI in public service systems and safety-critical sectors should be held to higher standards of transparency and accountability.
- Monopolisation of data and differential access to resources to build ML systems increases market inequities.
- Uneven distribution of technology gains can entrench existing societal inequities and create new ones.

Our Recommendations

- Policy interventions should be based on an evaluation of the social impact of ML applications.
- Investments in state and regulatory capacity, along with analog components of digital society are needed.
- Red lines should be drawn around certain types of use.
- Data protection frameworks need to be accompanied by community rights and accountability frameworks.
- Risk management approaches must be accompanied by upstream management of technological innovation processes.

1. Introduction

The potential of artificial intelligence (AI) to profoundly transform society, in ways both hidden and visible, is widely acknowledged. While the promise of AI-based technologies is enormous,[1] the challenges are equally staggering. Unguided AI development is likely to have complex risks associated with accountability, bias, privacy, unintended consequences and malevolent use.[2] AI applications are also precipitating uncertainty around future labour markets[3] and creating new questions for existing governance and accountability frameworks.[4]

According to a Nasscom report, AI has the potential to add $450-$500 billion to the gross domestic product (GDP) of India by 2025.[5] The Indian Government seeks to position India as a global leader in building and deploying solutions that can address developmental challenges in developing countries.[6] In 2018, NITI Aayog released the National Strategy for Artificial Intelligence in India, which, under the banner of AI for All, seeks to leverage AI for inclusive socio-economic growth and development.[7] The draft national strategy identifies five key sectors for AI interventions - healthcare, agriculture, education, smart cities and infrastructure, and smart mobility and transportation.

There has been a strong push from the Prime Minister's Office for AI to be central to the growth of the country and solve issues of poverty and disease.[8] In 2018, the Union government allocated INR 3073 crore towards research, training and skilling[9] in emerging technologies such as AI. In 2019, the government, in collaboration with the IT industry, set up Centres of Excellence in Bengaluru, Gandhinagar, Gurugram and Visakhapatnam.[10] In 2020, the government launched the National AI Portal and Responsible AI for Youth programme to provide a platform for knowledge-sharing and skilling in AI.[11]

1.1 Why this Study

Emerging discourses around the use of AI are polarised. On the one hand, a narrative of AI solutionism has taken hold, where AI is seen as a silver bullet to address complex and persistent problems of development, like health[12] and education.[13] At the other extreme, AI is seen as a grave threat to civil liberties and job futures. Discussions on AI governance also refer to broad principles, such as fairness and equity, which can have differing implications across diverse social contexts.

With this study, we wish to take a snapshot view of the various ways in which AI is in use across key sectors in India, in order to determine which areas of application require public scrutiny and debate. Innovations that deliver value to society require the social shaping of technology to ensure that the technological trajectories are equitable and add value at all levels of society. Public scrutiny and policy steering of AI trajectories will therefore be critical.

There is currently no mapping of AI use and the AI ecosystem in India, from the actors and sectors, to use cases and institutions. Social science research on the development, deployment and impact of AI in India is at a nascent stage. Most conversations around the impacts and risks of AI are based on the research and experiences of industrialised economies. Research grounded in India's unique context is needed to identify key questions, issues and sectors relevant for India.

1.2 What is Artificial Intelligence ?

Artificial Intelligence refers to a field of study within computer science that aims to develop computational applications that can mimic human intelligence. This makes defining AI a moving target - human intelligence is vast and as computational techniques progress, the benchmark for what constitutes human intelligence keeps changing. Greek myths contain stories of mechanical men designed to mimic human behaviour and early European computers were conceived as 'logical machines', reproducing human capabilities such as arithmetic and memory.[14] As technology and our understanding of how our mind works has progressed, the concept of what constitutes AI has also changed.

Much of the recent interest in AI is because of advances in machine learning. Machine learning is a type of AI that refers to the ability of a machine to improve its own performance through experience. Machine learning algorithms build a mathematical model based on sample data, known as "training data", in order to make predictions or decisions without being explicitly programmed to do so. A huge increase in the amount of data, computational power, and data storage capacities has enabled recent advances in machine learning. Machine learning is what drives applications such as movie recommendations from streaming services, product recommendations on e-commerce platforms, self-driving cars, speech recognition and facial recognition and effective web search, among many other applications.

However, not all algorithms can be called machine learning algorithms. In computer programming, an algorithm, much like a cooking recipe, refers to a set of instructions which can be used to achieve a particular goal. Traditional algorithms can be understood as a series of if-then propositions, that explicitly set the criteria of action. Take for example, self-driving cars. Using ML algorithms, one can teach a computer to drive a car, by training it on data from thousands of driving hours by various drivers. This means that a machine learning or AI algorithm can be trained by providing an input (point A) and an output (point B), without explicitly defining the process of how to get from point A to point B. In the case of traditional algorithms, however, this would have to be done by manually coding in rules that set the criteria for action. The programmer would have to code in the criteria that if the computer identifies an obstacle on the road, it has to push the brake.[15]

In recent years, many of the advances in AI have been possible due to the advances in a specific class of machine learning algorithms known as deep learning. Inspired by the structure of the human brain, deep learning algorithms utilise neural networks to analyse patterns from data.[16] Modeled loosely on the human brain, a neural net consists of thousands, or even millions of simple processing nodes that are densely interconnected. The key difference between other machine learning algorithms and deep learning emerges from the way in which data are presented to the system. Machine learning algorithms 'learn' from structured data, that are labelled inputs, whereas deep learning does not require labelled data. In 2012, Google Brain used unsupervised learning to train an AI model to recognise images of cats, without labelling a single image as that of a cat.[17] Another famous example of a deep learning algorithm is the Go playing programme, AlphaGoZero developed by DeepMind. The system in AlphaGoZero was trained without any inputs or human knowledge, other than the rules of the game (such as how the pieces move on the board and how points are scored).[18]

ML-based applications are also incorporated in allied fields such as computer vision or natural language processing. A subfield of AI, computer vision refers to a field of study which seeks to develop techniques to help computers "see" and understand the content of digital images such as photographs and videos.[19] Similarly, natural language processing combines interdisciplinary approaches from linguistics, computer science, and artificial intelligence in order to programme computers to process and analyse large amounts of natural language data.[20]

AI as a technology has certain technical features, but a more nuanced and social view of AI is needed in order to understand the challenges of its use and application. AI needs to be perceived as a 'socio-technical system' - a system that does not function autonomously, with an inner 'technological logic' only, but is the outcome of the activities of social systems for the production, diffusion, and use of technology.[21] Understanding AI as a socio-technological system directs attention to the myriad human decisions which enter into the workflow of developing as well as deploying AI. These decisions

are also contextually situated within socio-cultural systems and are influenced by historical, material as well as social conditions. For example, whether or not to use AI to predict criminal recidivism is rooted in institutional and cultural norms and beliefs as much as it is dependent on the availability of such systems.[22]

Advances in machine learning in recent years can improve efficiency, fuel innovation, and provide novel solutions to complex problems. Many of the benefits are already perceptible - from everyday uses such as language translation to more complex applications such as early disease detection and increasing crop yield. For example, Microsoft's translator application now supports 12 Indian languages - including Assamese, Gujarati, Telugu, and Urdu - that could open up access to a world of information for native language speakers.[23] Microsoft has partnered with International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to develop an application that helps farmers improve farm productivity.[24] A pilot study conducted with a group of farmers showed that farmers who followed recommendations made by the app increased the yield of their crops by 30%.[25]

But AI also poses harm and risks. Because AI systems tend to rely on historical data, they also reproduce the biases and blindspots in the data. This could result in unfair and discriminatory outcomes. For example, studies in the US have found that healthcare risk-prediction tools[26] and criminal recidivism-prediction tools are biased against African-Americans.[27] In the case of healthcare risk-prediction, researchers found that a widely used tool to predict which patients were likely to need extra medical care, heavily favoured white patients over black patients.[28] There are concerns around the learning process of machine learning. Certain patterns that are established or certain inferences drawn are neither visible nor easily comprehensible. This raises concerns about explainability and transparency. In recent years, well known examples of unethical and dangerous use cases of AI have surfaced around autonomous warfare[29], surveillance[30] and behaviour profiling in elections.[31] Additionally, surveys conducted by Udemy show that many workers (76%) in India expect their jobs to be fully automated by 2025.[32] Research by Pew shows that about 52% of experts in North America feel that AI will not displace more jobs than it creates, whereas 48% argue that it will.[33]

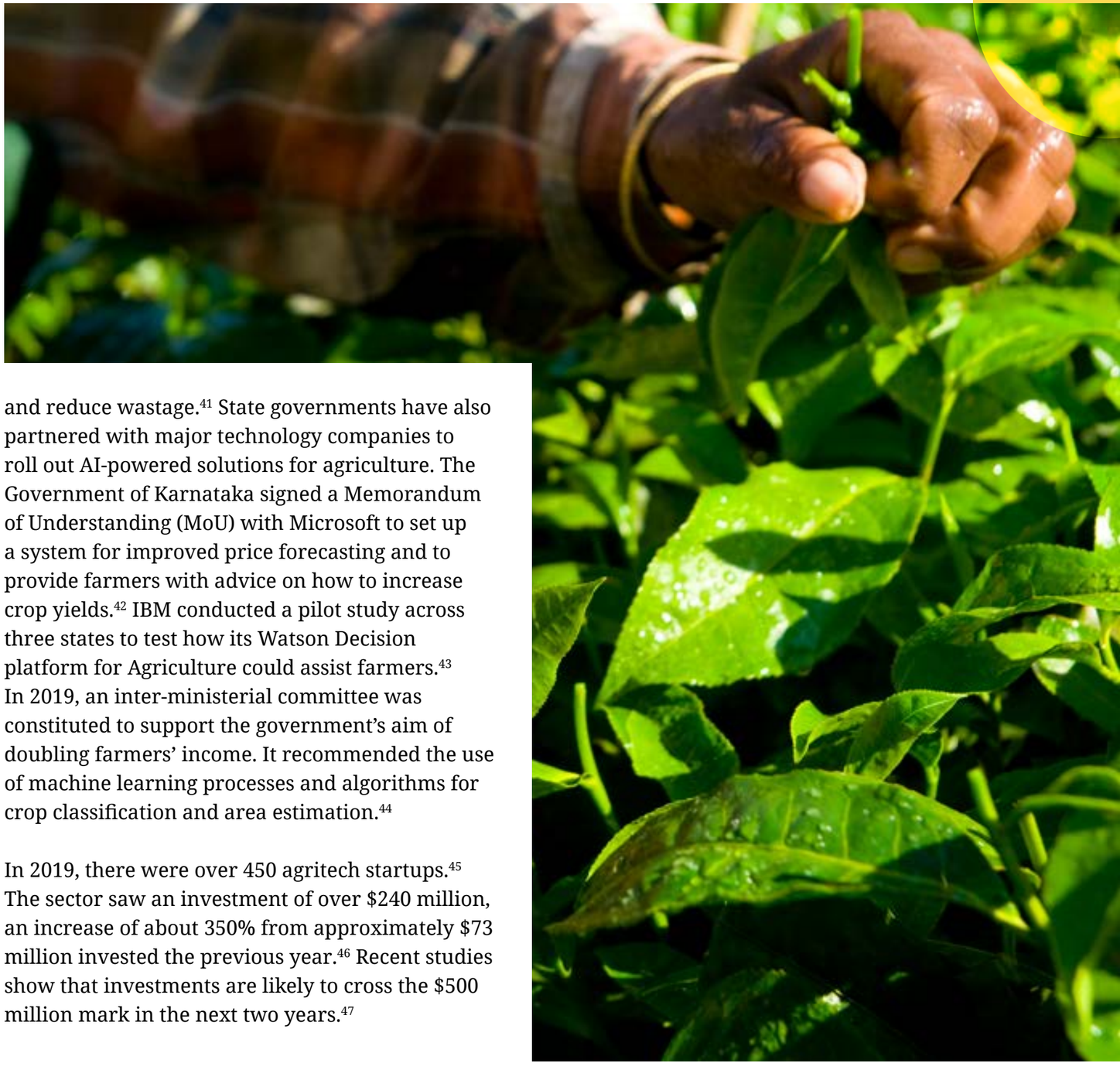
1.3 Method

As noted above, there is no clear definition of AI and the boundaries of what constitutes AI is widely debated. For this study, based on research conducted between June and December 2019, we focused on the use of machine learning across various sectors in India. Through databases such as Crunchbase and Angel list, we first identified companies which self-identified as using ML.

We identified 150 use cases of AI being implemented across 16 different sectors in India. Annex II of the report provides a comprehensive list of all the use cases of AI identified through primary and secondary research. Out of the 16 sectors, we selected 9 key sectors, which called for greater public scrutiny or which had the highest likelihood of social implications, for further inquiry. The 9 sectors selected are: agriculture, banking and financial services, education, energy and water, enterprise solutions, healthcare, policing, public tech, and workplace.

The aim was to collect a representative sample of use cases across sectors to identify the particular opportunities and risks in that sector, and whether certain issues require further scrutiny. The field of AI is rapidly evolving, with new companies and applications emerging at a fast pace. Since the time of this research, many new applications have been developed, some of which pose new opportunities and risks. The study is not intended to be a comprehensive mapping of the use of ML, but as an indicative snapshot of how ML is being used in key sectors and its possible benefits, harm, and challenges.

2. Agriculture



The agriculture sector in India accounts for about 16% of the GDP[34] and 42% of total employment.[35] 70% of households in rural India depend predominantly on agriculture for their livelihood.[36] In recent years, the Government has introduced several policies, such as a National Agricultural Market (eNAM), to tackle challenges in the sector.[37] Some instances of ongoing ICT-based interventions are land-record digitisation (Bhoomi project in Karnataka)[38] and the digitisation of credit and financial services for farmers through the Kisan Credit Card (KCC).[39] The government has also set up 713 Krishi Vigyan Kendras and 684 Agricultural Technology Management Agencies across districts to disseminate technologies among farmers. [40]

Agriculture was one of the focus areas of the National AI strategy document released by NITI Aayog in 2018. The strategy document asserts that AI and related technologies have the potential to improve productivity and efficiency across all stages of the agricultural value chain and can help increase farmer income and farm productivity and reduce wastage.[41] State governments have also partnered with major technology companies to roll out AI-powered solutions for agriculture. The Government of Karnataka signed a Memorandum of Understanding (MoU) with Microsoft to set up a system for improved price forecasting and to provide farmers with advice on how to increase crop yields.[42] IBM conducted a pilot study across three states to test how its Watson Decision platform for Agriculture could assist farmers.[43] In 2019, an inter-ministerial committee was constituted to support the government's aim of doubling farmers' income. It recommended the use of machine learning processes and algorithms for crop classification and area estimation.[44]

In 2019, there were over 450 agritech startups.[45] The sector saw an investment of over $240 million, an increase of about 350% from approximately $73 million invested the previous year.[46] Recent studies show that investments are likely to cross the $500 million mark in the next two years.[47]

Main AI-based interventions

We have identified 3 types of AI-based product interventions in the agriculture sector.

Precision farming and Agribots

Precision farming systems gather data at the farm-level, co-relate them with publicly available weather forecasts, and generate insights to help farmers make optimum use of seeds, water, pesticides and fertilisers. These systems also alert farmers about crop health and potential pest attacks. Agricultural robots or agribots are used to carry out tasks such as planting seeds, weeding, and harvesting.

Start-ups such as Fasal are using computer vision and AIoT sensors to collect farm-level data, which they combine with weather data to provide farmers with real-time reports detailing crop health. The data are also used to predict ideal growth conditions and resource requirements. Fasal currently operates in over six states and plans to expand across India and also enter Southeast Asian markets.[48] Similarly, Microsoft and ICRISAT, in association with the Andhra Pradesh government, have developed an application that helps farmers improve farm productivity.[49] Using data about weather conditions and soil health, the application lets farmers know the ideal time to sow seeds. A pilot study done with a group of farmers who followed the application's recommendations showed a 30% increase in yield.[50]

TartanSense, a start-up, is building small robots for small farms. Their agribot, Brijbot, is a semi-autonomous rover that uses computer vision for de-weeding.

Farm-to-Market Supply Chains

There are instances of machine learning-based systems being deployed to optimise agricultural supply chains, reduce produce wastage and match supply to demand. Krishihub connects farmers directly to businesses and uses ML to optimise logistics and reduce wastage. Gobasco, an online marketplace, uses real-time data analytics and algorithms to automate the supply chain and streamline it. Sensovision Systems and Occipital Tech are start-ups that use a combination of computer vision, ML and robotics to inspect produce quality and provide automated grading and sorting solutions at various points in the supply chain.

Financial Solutions for Farmers

In some instances, computer vision and IoT sensors are being used to collect data about individual farms to improve benchmarks for insurance premiums, assess damage to speed up pay-outs, and assist government schemes with evaluations. For example, Cropin, through its service SmartRisk, generates alternate agricultural data for decision making, allowing potential lenders and insurers to carry out credit and crop risk assessments. Cropin's machine learning systems are also used to analyse the overall crop yield of a village. This has informed the government's decision-making (under the Pradhan Mantri Fasal Bima Yojana), on the disbursal of crop insurance claims to farmers.[51]

ICICI Bank has been using satellite images of farms to assess crops, and subsequently farmers' creditworthiness.[52] IBM is developing a credit-scoring application which will help determine a farmer's average yield and profit. This will provide an estimate of the farmer's creditworthiness.[53]

Challenges for adoption

Most companies working at the farm level struggle to obtain sufficient data to train their models for high accuracy.[54] The absence of both micro-level data (about farms) and macro-level data (about the agricultural sector) also makes it difficult to identify where interventions are needed the most.[55]

The rate of farm mechanisation in India is around 40%, which is fairly low compared to rates in countries like China and Brazil (60 and 75% respectively).[56] This poses a challenge for AI deployment. Businesses offering AI solutions prefer working with farmers whose farms already have some degree of mechanisation, as they are more accepting of technological solutions.[57]Aside from farmer buy-in, other challenges in this sector include insufficient digital connectivity and low digital literacy amongst the target population.[58]

Farmers with large landholdings are the only ones able to afford these technologies.[59] Moreover, NSSO data show that farmers with small landholdings only make a small amount from cultivation. This might reduce their incentive to invest in new technologies for cultivation.[60]

Prior research indicates that subsidies have been a key mechanism through which governments in India have driven technology adoption in farming.[61] Without extensive subsidies provided to small and marginal farmers, adoption is likely to remain low.

Potential benefits

Data science and AI can provide accurate and actionable information which could help improve farmer productivity and incomes.[62] Advisory solutions are expected to enable efficient consumption of water and targeted use of pesticides, making the practice more sustainable. Information about farm conditions gathered using AI and IoT can also be used to evaluate farms and provide farmers with credit and insurance.

Solutions working across the agricultural supply chain could potentially reduce wastage, match supply to demand, and improve farmer incomes. Current estimates suggest that approximately 16% of produce is wasted every year.[63]

Research has demonstrated that deep learning algorithms can effectively identify diseases across species of plants with 99% accuracy.[64] Precision agriculture systems could also reduce the amount of water used for irrigation.[65]

Potential harm

Currently, the digitalisation of agriculture in India is being spearheaded by agritech startups, but is often based on anecdotal evidence, or on the experience of developed nations.[66] For example, a study recently conducted in the northeastern and midwestern regions of the United States found that while precision farming is claiming to plug gaps in farmers' knowledge through data-driven farming, in reality the farmer's role is being relegated to that of a data operator.[67] Far more research is needed to understand the impact of digital technologies, including AI, on the sector and on farmers.

Earlier waves of corporatisation in the agricultural inputs markets, for seeds and pesticides, were accompanied by a sharp rise in prices of intermediate inputs in agriculture. Data released by the Ministry of Agriculture indicate that the rising cost of intermediate goods has been the biggest reason for the decline in terms of trade (ratio of export price to import price) for farmers.[68]

The introduction of AI-based technologies can further increase the dependence of farmers on large companies that operate across the agricultural value chain, selling seeds, fertilisers, and equipment, transporting produce, and also purchasing it. Most agricultural advisory interventions relate to seeds, fertilisers, and market prices. Advisory inputs, which are driven entirely by market demand, can be co-opted by companies that invest across the agricultural value chain. For instance, as a recent study by IT for Change argues, the merger of Bayer and Monsanto is an attempt to fuse complementary data sets of soils and seeds. These data allow the company to recommend best practices to farmers through AI-driven analysis of the soil and seed data and also sell them subsidised seeds. In doing so, they could arguably be pushing a dependency model which favours the company.[69]

Further, price and market advisories could lead farmers to grow produce that provides the highest income. If unregulated, this could lead to other crops being neglected, leaving the country no option but to import those crops.[70] These advisory frameworks also run the risk of error, but there are no systems in place to compensate farmers for crop failure or other adverse outcomes resulting from errors in the advisory interventions.

Additionally, since the sector accounts for 42% of employment in India,[71] AI-based automation is likely to adversely impact employment. Automation of farm tasks is also likely to have a more adverse impact on women, who according to National Council of Applied Economic Research (NCAER) research comprise 42% of the agricultural labour force in India, but own less than 2% of the agricultural land.[72]

3. BFSI

Banking, Financial Services and Insurance (BFSI) are increasingly looking to ML-based applications to improve service delivery and efficiency of internal processes. In 2017, the global IT spend of the Banking and Securities industry was about 19%, towards use cases such as automated trading and investment discovery, trading strategies, robo-advisors, and customer behaviour analysis.[73]

The BFSI sector in India is witnessing a similar integration of ML into existing systems. According to NASSCOM, there is a growing recognition of the need for AI amongst banks, FinTech, and insurance companies.[74] According to research by the National Business Research Institute and Narrative Science, about 32% of financial service providers in India are already using AI technologies such as predictive analytics and voice recognition.[75] Regulatory bodies such as the Reserve Bank of India (RBI) and The Securities Exchange Board of India (SEBI) have also introduced guidelines for AI use. In 2012, SEBI introduced guidelines on algorithmic trading[76] and in 2017 introduced norms to make algorithmic trading more accessible.[77] Similarly, in 2016 the RBI set up an Inter-regulatory Working Group on FinTech and Digital Banking to develop a deeper understanding of various FinTech products.[78] It also released a report in 2018 with recommendations which specified a sandbox to test innovative products/services such as wealth management and financial advisory services, and technologies using AI and ML.[79]

In 2020, the Institute for Development and Research in Banking Technology (IDRBT) established by the RBI, in association with Microsoft India, released a whitepaper on AI in Banking.[80] In the whitepaper, the IDRBT suggests the use of an AI Maturity Assessment for banks to assess their readiness and level of maturity to use AI, and to identify steps for the adoption of AI. Additionally, the Union budget for 2020 has declared plans to use AI for fraud detection in the Ayushman Bharat scheme.[81] The Finance Ministry has also been exploring the use of AI in detecting tax fraud.[82]

Main AI-based interventions

We have identified 3 types of AI-based products and services in the sector.

Enabling financial and banking services for new customers

New credit scoring methods using ML algorithms are being deployed to onboard new customers. Traditional lending has been largely dependent on customer credit history but for those who have not taken loans nor have a traceable financial history, machine learning uses alternative attributes to determine a user's credit score. This is determined on the basis of mobile or utility bills, social media and cell phone messages that indicate the user's spending activity[83] among other available data points, forecasting the amount that can be borrowed and the ability of the individual to make payments.[84] Companies like i3systems, through partnerships with HDFC Bank and MaxLife Insurance, provide alternative credit scores to those without assets or banking histories.[85]

Banks are also exploring the use of natural language processing, and voice recognition to build processes that help cater to populations with low levels of literacy. For example, Navana tech (formerly litOS) is using natural language processing (NLP) to create voice-powered chatbots that can make it easier for populations with low levels of literacy to access services. CreditMate is one of the companies that creates loan pay-back scores for borrowers using ML algorithms. Its product also provides nudges to consumers to remind them to pay their loans.

Improving financial and banking services for existing customers

Banks have begun exploring the use of ML applications to improve customer engagement, experience, and services through chatbots and voice authentication systems. ICICI Bank's AI-enabled virtual assistant iPal supports a large number of customer queries and enables location/branch searches.[86] In order to improve customer experience, HDFC Bank is also considering Gesture Banking, which uses computer vision to detect gestures and develop an interface for customers to navigate systems at kiosks, using gestures.[87]

Investment firms, such as IndMoney, are leveraging ML - for example with their wealth management application IndWealth - to generate customer insights in order to personalise their service offering to clients and for wealth management. Another example is Tata Quant Fund, which uses ML to assess a client's risk appetite, in order to suggest appropriate investment portfolios.[88]

Payment systems of companies are able to prompt tailored modes of payment such as EMI or UPI at the time of checkout, by employing AI to analyse the past payment patterns of a user.[89]

Increasing efficiencies of internal and operational processes

Insurance companies are adopting AI systems to optimise the processes of claims assessment. For this, computer vision is being used to assess damages and ML systems are being used to verify information. ICICI Lombard uses ML to predict an optimum claim amount, based on the policy sum insured and additional relevant parameters.[90]

Firms are exploring the use of ML to digitise the Know Your Customer (KYC) process to detect fraudulent customers and remotely onboard new customers. Similarly, image recognition-based KYC, where customers record themselves to provide proof of identity, is being used to verify customers. Optical Character Recognition (OCR) systems are able to digitise documents and thus automate customer onboarding. ML models also help to optimise cash levels in ATMs.[91]

There are instances of ML being used to execute trading orders by optimising asset valuation. ML models learn from previous data points of the asset to predict the future valuation. The Bombay Stock Exchange has launched an ML system to track news related to listed companies to detect and mitigate any risk of market manipulation and reduce information asymmetry arising from it on digital media platforms.[92]

Challenges for adoption

A key challenge is the availability of the correct and verified data. Mistakes are often made at the time of data entry, either by customers or banking institutions. Updating the skills of the existing workforce to adapt to these applications is also a challenge.[93]

Further, many customers have low levels of digital and financial literacy. Research shows that many are more comfortable with oral forms of communication, rather than numbers or text, and thus may still prefer direct human interaction.[94] Access to this portion of the population is additionally constrained by the limited number of vernacular languages that AI and ML can currently process.[95]

Banking and financial institutions in India are currently regulated by a patchwork of regulatory authorities. This makes it hard for companies to navigate the regulatory landscape. SEBI, for example, has issued guidelines on algorithmic trading; the Insurance Regulatory and Development Authority (IRDA) has guidelines on wearables; and RBI has issued guidelines on digital payments.[96] Banks in India are also more closely regulated than FinTechs. Therefore, while regulatory oversight is critical for adoption, overly strict regulations on the use of AI could disincentivise banks from adopting AI solutions.[97]

Potential benefits

Big data analytics and ML in credit scoring systems could provide an alternative way to onboard new customers, especially catering to those in the unbanked segment in India.[98] ID Analytics, a risk solutions company, released a whitepaper that examined credit applicants across industries, using an alternative credit score developed by the company called Credit Optics Full Spectrum. In its research it found that, based on this score, 10-40% of previously unscorable applicants would be considered as credit-eligible without additional risk.[99] Additionally, the development of solutions using text-free, local language-based voice, and also image-based software could create means to overcome the literacy barrier that contributes to the financial exclusion of a large section of potential users.[100]

Tailored products for existing customers can also provide better service delivery by banks and financial institutions through personalised wealth management methods.[101] ML systems can recognise patterns from large datasets and identify trends in customer behaviour, to be able to create products based on a curated risk-profile of an individual.[102] Similarly, the use of AI in backend operations could help this sector to improve efficiency and cut losses - through fraud detection, tailored business insights based on data analytics, improved security, and quicker turnaround time. Danske Bank employed Teradata, an AI firm supplying fraud detection solutions for banks, and saw an increase in detection of fraud by 50% and reduced false positives by 60%.[103] The use of robo-advisors is gaining momentum in the investment sector. It uses data analytics, deep learning and ML to create portfolios tailored to the client's needs on the basis of various parameters. Sentiment analysis could also be used to predict trends for traders and investors, based on market sentiments or through social media/news related to the investor's interest.[104]

Potential harm

AI-based systems for alternative credit scoring and personalised services can result in privacy violations. Mobile phones through installed apps, transactional SMSes and location services, are important sources from which companies mine data points to provide alternate credit scores.[105] Most apps access the individual's contacts, storage, photos, and audio and while user consent is acquired, people don't often read or understand the terms and conditions.[106] One developer from our interviews claimed they could extract over 10,000 data points from these sources.[107] A few FinTech companies have also been in the news recently for unauthorised data collection from applications installed on a customer's phone.[108]

Data on user behaviour could also be used to discriminate or cause harm. A study in the United States found that some FinTechs that used AI models to underwrite loans, charged borrowers from minority groups higher interest rates.[109] This is particularly problematic because credit scoring algorithms are proprietary to the companies that develop them, making explainability and accountability of the algorithmic models a further challenge. Over time, this could reduce trust in the financial institutions that employ these systems.

There are still concerns around inaccurate data at the levels of input as well as processing through data analytics. This is likely to affect verification in claims assessments[110], asset valuations, or even personalising services for the creation of risk profiles and investment portfolios. The use of image recognition could also potentially misidentify individuals in carrying out KYC processes or fraud detection as these processes rely on factors such as image quality, accurate orientation, and template.[111]

Identity fraud through deep fakes, voice hacks, and identity impersonation,[112] and cyber crime are also significant risks. The recent hack on Cosmos Bank in Pune from North Korea demonstrates the many techniques available to hackers attacking through malware or compromising the bank's messaging environment.[113]

Repetitive and predictive roles such as tellers, are being automated, customer service reps are being replaced by chatbots, and robo-advisors are replacing expensive investment experts.[114] As a result, with the deployment of AI becoming more viable, the sector could witness the significant reshaping of jobs and short-term job loss.[115]

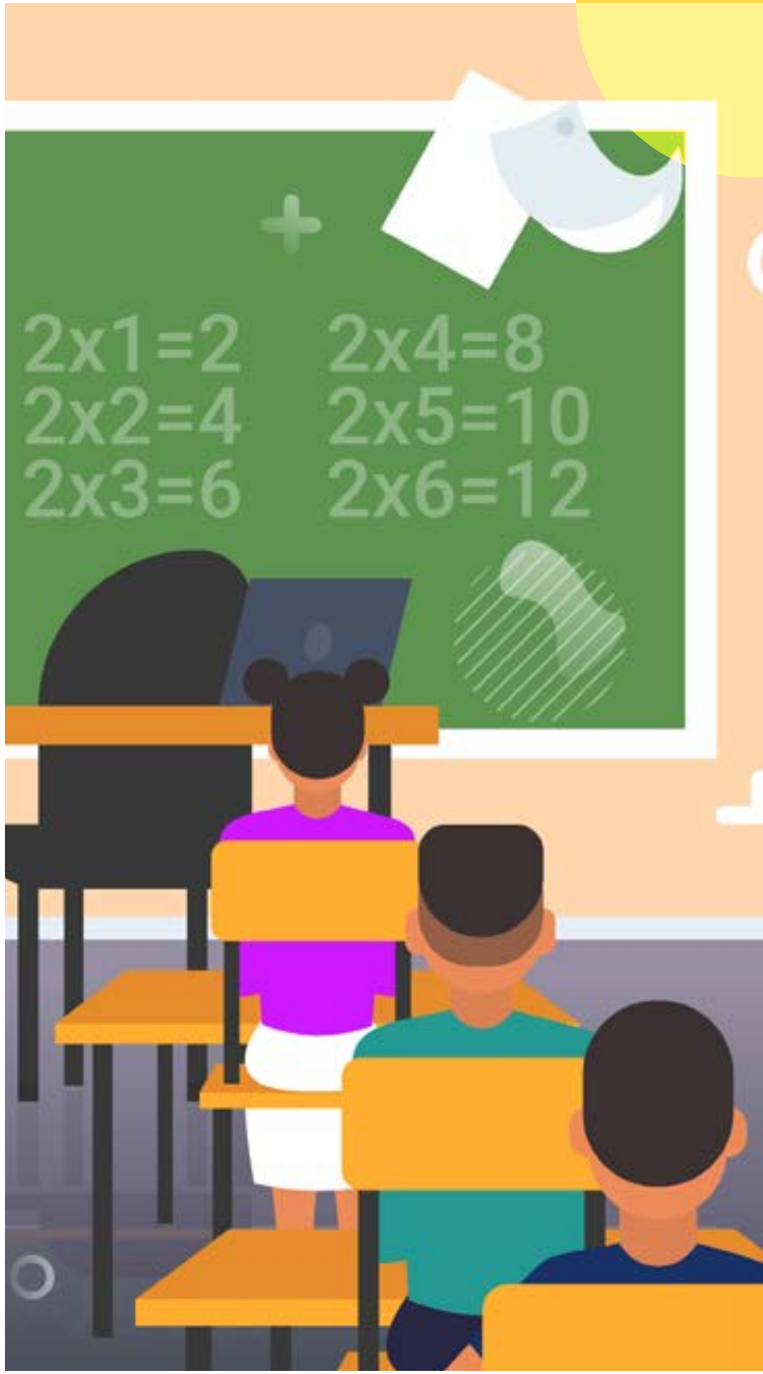
4. Education

The Government of India sees Artificial Intelligence (AI) as enabling improved access to quality education. In 2018, NITI Aayog's National Strategy for AI identified education as a priority area.[116] In the National Education Policy (2020), AI takes a central role in education, both in the early years and at university level. AI will be used to track and record the training of children to provide them with a data-driven 'holistic report card."[117] The Central Board of Secondary Education (CBSE) in India has introduced AI as a core part of the curriculum.[118]

Several state governments have collaborated, or are in the process of collaborating, with technology companies to incorporate AI into the delivery of education. For example, in 2017 Andhra Pradesh, in collaboration with Microsoft India, used AI to predict student dropouts in government schools.[119] Tamil Nadu has piloted AI-based biometric attendance systems in schools.[120] The CBSE, in collaboration with Microsoft India, has launched a skilling initiative to conduct training on AI use for K12 CBSE teachers.[121]

The EdTech sector is also growing. From 2014 to 2019 EdTech companies in India received over $1.8 bn in investments[122] and there are currently more than 3,500 companies in the EdTech space in the country.[123] Global VC funding for EdTech has also been steadily on the rise, with a 4x increase from $1.8 bn in 2014 to $8.2 bn in 2018. India is the third largest receiver of global VC funding in EdTech, after China and the U.S.[124] According to a 2019 Google and KPMG report, the user base for digital education in India is also expected to grow from 1.6 million users in 2016 to 9.6 million users in 2021.[125]

The increasing use of EdTech platforms generates multiple data points which can be used to build AI products and services for education. Some of the largest EdTech companies such as Byju,[126], Toppr,[127], and Khan Academy[128] are already using AI in some of their products and services. Additionally, several Software as a Service (SaaS) or Platform as a Service (PaaS) startups have sprung up in this space, building AI-based products and services for education in India. [129]



Main AI-based interventions

We have identified 7 types of AI-based interventions.

Personalised and Adaptive Learning

Personalised and adaptive learning encompasses the use of ML algorithms to assess a student's proficiency and the tailoring of learning material to individual needs.[130] Personalised and adaptive learning as a pedagogic method has been in use even without AI, but with the use of machine learning models, the assessment and personalisation has become more microscopic, with granular and continuously generated data points. Companies which use ML for personalised and adaptive learning services in India include Jungroo Learning, Mindspark and Embibe.

Platforms that offer Massive Open Online Courses (MOOCs) are exploring the use of AI to help design and personalise communication in the form of nudges to improve user engagement to help achieve higher completion rates. ML algorithms allow MOOC platforms, such as Khan Academy, to predict the likelihood of a student answering the next question correctly. Such data are then used to personalise learning by providing nudges and suggestions. For example, if a student is struggling with a particular problem, the platform could nudge the student to watch a video or take a break.[131]

In addition to a subscription-based model, Jungroo Learning has also partnered with non-profit organisations, such as Teach for India and Bhumi, to roll out their adaptive learning and assessments platforms in partner schools in India.[132] Mindspark has been adopted by more than 178 schools, both public and private, in India, and is also available in at least two languages other than English.[133] Embibe claims to have over 15 million students as users of the platform.[134]

Remote Proctoring

In some instances remote proctoring systems are being used for online examinations. Remote proctoring incorporates AI-based facial recognition and movement detection systems, verifies students' identities and monitors them during the exam. In 2019 Anna University in Tamil Nadu hosted campus placements for Cognizant using a remote proctoring service.[135] Most IT companies make use of remote proctoring systems for campus placement tests at Indian universities.[136] In 2019, the Uttar Pradesh government announced plans to introduce AI bots in classrooms to monitor proxy invigilators and students during exams.[137] In India, companies such as UpGrad, MercerMettl, ProctorU, and Wheebox provide this service.[138]

Prediction of School Drop-outs

ML applications can be used to predict school drop-out rates. This information can then be used to develop systems to reduce dropout rates. In 2017, the Andhra Pradesh government, in collaboration with Microsoft India, used ML to predict school drop-out rates for students attending government schools in the state.[139] The ML platform was utilised to identify key factors which led to drop-outs.[140] According to reports, the platform identified 19,500 probable dropouts in the Visakhapatnam district in the academic year 2018-2019. This information was used to track and counsel these students in order to prevent dropouts.

Provision of Educational Loans

AI-based FinTech companies are using ML to predict a student's future earning potential in order to underwrite education loans, thus moving away from traditional loan underwriting methods used by banks, such as assessing family asset value and income. In some cases, platforms also aim to help match students with the right scholarship opportunities. In India, Credenc offers education loans to students based on alternate credit scores, factoring in as many as 15 million data points to assess the creditworthiness of student applicants.[141] Apart from Credenc, a handful of other companies such as Credelia, Shiksha Finance and Eduvanz are also operating in this space.

Career Counselling

ML applications are also being used to match students with prospective colleges and programmes and provide insights into where a student has a high probability of acceptance. This allows students to narrow down their options and cut through a mountain of information in order to make data-driven career decisions. Leverage Edu, WUDI, Mindler are examples of companies in India which provide this service. According to reports, Leverage Edu has about a million monthly users; [142] and Mindler had about 50,000 users in 2017.[143]

NLP for low literacy and multi-lingual contexts

In some instances ML systems for NLP tasks, such as converting speech to text, or text to speech and language translations, are being used for language education and to improve the communication skills of students. Learning Matters, for example, deploys a cloud-based, NLP-based virtual voice assistant, branded as 'TARA', in government schools in Chennai.[144] The company has signed an MoU with the Government of Karnataka to provide educational solutions in the districts of Yadgir and Raichur and has also pitched TARA to the Ministry of Human Resource Development for a project across schools in Chandigarh.[145]

Facial Recognition for School Attendance

Government schools in Tamil Nadu[146], Telangana[147] and Delhi[148] are using ML learning-based computer vision systems for facial recognition. In Tamil Nadu, the government has piloted AI-based biometric attendance systems in schools, aiming to scale up to 3000 schools in the state.[149] In 2018, Microsoft's Kaizala app was slated for launch in primary government schools in Gujarat, to mark teachers' attendance and curb absenteeism. It was scrapped later due to protests from teachers.[150]

Challenges for adoption

There are 1.5 million schools in India. Many of these are located in rural areas without access to basic infrastructure such as electricity and internet connectivity. The District Information System for Education (DISE), a database developed by the Ministry of Human Resource Development (MHRD), has indicated that only 53% of the total government schools, which make up a huge chunk of the schools in rural India, have access to electricity. Only 28% of all schools have access to a computer (the number shrinks to 18% for government schools), and 9% have access to the Internet (4% in the case of government schools).[151] Many educational institutions in India do not have digitized data and electronic resource planning systems.[152]

Buy-in as well as the training of teachers is needed for these technological interventions to scale. The CBSE, for example, has a number of EdTech initiatives, but low investment in teacher training, particularly in rural areas, has limited their uptake.[153]

Potential benefits

The problems of low teacher to student ratio (1:24) in Indian schools[154], and the low skill and employability levels of graduates[155], could be solved through AI-based personalised learning tools. These could improve student learning outcomes and employability.

A study evaluated the efficacy of MindSpark's personalised and adaptive system compared to traditional methods, and found that there was a marked improvement in students' language and mathematics learning outcomes.[156]

Assigning chatbots to students to take care of basic questions and answers, could help augment the role of the teacher and reduce teacher burden. Data driven decision-making to guide career choices and discovery can help students find relevant career paths. Alternate credit scoring methods can help individuals from lower income households to access financial aid for higher education.

Increasing the text and speech data corpus for vernacular languages in India also provides the opportunity to impart education in vernacular mediums. For example, the use of NLP for accurate language translation can help students convert their textbooks into their mother tongue.

Potential harm

The use of AI for education raises concerns around privacy. For example, the Andhra Pradesh government tapped into three databases for Microsoft's AI system to predict school dropouts in the state - the Unified District Information System for Education (U-DISE); educational assessment data; and socio-economic information from the UIDAI-Aadhaar system.[157] The combination of datasets could pose a significant threat to privacy. Further, parents or guardians may not always understand how or why data about their children are being collected and used.

The use of AI can also reduce children's capacity for self-determination, as they are categorised as having a certain skill level or set of interests. This could be particularly harmful for younger children at an early developmental stage.

The use of AI to assess learning outcomes and evaluate performance could also produce discriminatory outcomes, if the impact of social drivers of student performance, such as gender, class, and caste, are over-represented or absent from the training data set.

Recently, AI was used to assess student examinations in the UK. The grades were calculated based upon factors such as the historical grade distribution at the school; the classes' previous year exam results and the grade distribution of previous year groups.[158] As a result, poorer students and those studying at state-provided schools were more likely to have received lower grades. Private fee-paying students, however, were awarded more than twice as many A* and A grades compared to comprehensive state schools. The results were branded "shockingly unfair", favouring pupils at private schools, who already have significant academic and professional advantages over state school pupils. [159]

The increasing datafication of education can contribute to the shrinking agency and role of teachers.[160] In countries like the UK, where datafication of school environments is more extensive, studies show that data-intensive practices can end up reducing the role of the teacher, from the provider of information to data producer and analyst.[161]

There is a risk that the use of personalised and adaptive learning systems could reduce introspective and independent thought.[162] Learners could become over-reliant on these systems, dependent on nudges and tailored lesson plans, which in the long run could affect the development of higher order thinking skills.

Many government schools, particularly in rural areas, lack access to the basic infrastructure needed to utilise AI and digital technologies. Low-income families may not be able to afford the cost of these services. The use of AI could amplify existing gaps in the access to quality education, with students in urban areas, or private schools, better able to benefit from AI-based applications.

5. Water and Energy

The global energy industry is looking to AI solutions to catalyse the shift towards clean energy. A recent market intelligence report estimates that investment in artificial intelligence in the energy market will reach $7.78 billion by 2024, witnessing a CAGR of 22.49% from 2019 to 2024. The report attributes this to the demand for operational efficiency and concern for energy efficiency.[163] AI is also being considered to further alternative means of global water management, and work towards meeting the Sustainable Development Goals.[164]

India's National Draft strategy for AI suggests leveraging of AI by smart cities to augment some of the applications being developed for energy and water management.[165] In 2018, The Ministry of Water Resources collaborated with Google to develop an AI model to forecast floods.[166] Atal Bhujal Yojana, the World Bank supported national groundwater management improvement programme, also intends to strengthen the implementation of the programme through AI.[167]

Main AI-based interventions

We identified 2 types of AI-based products and services in the sector.

Optimising consumption and generation

There are several instances of ML applications being utilised for the purpose of smart consumption, to continuously monitor and optimise the consumption of energy resources for efficient use. To do this, AI/ML is employed to derive insights from the data of energy operations to provide approaches for optimum consumption. For instance, Bidgely, an energy analytic company, uses ML to itemise the data on electricity consumed by different appliances used at home, to provide an estimate of how much energy an appliance consumes. Based on the varying consumption patterns of the different appliances, it provides recommendations to save on electricity consumption. Performing a similar function but on a smaller scale is Sustlabs, through its product called Sustlabs Ohm. The device is attached to the electricity meter and then connected to the consumer's mobile phone to generate real-time insights about energy usage and house activity based on consumption. It also allows users to set limits and provides alerts if the consumption limit is exceeded.

On a larger scale, there are instances of ML being leveraged to make wind power more predictable. It is being improved by introducing data that are more valuable for wind farm operation, such as weather forecasts, both historical and live feed-in data, and meta data from the farm such as generation capacity or exact location of the turbines.[168] These data allow wind farm operators to better assess whether the power output can meet the electricity demand.[169] Mahindra TEQO, an asset management company, provides a wind farm analytics solution called WindPulse. It uses ML to forecast power generation and predict maintenance requirements to keep track of the health of equipment, thus ensuring improved productivity and revenue of wind farms.

To maximise solar power generation, the SaaS platform introduced by The Solar Labs is being used to optimise the process of installing solar systems.[170] The platform conducts an analysis of the rooftop remotely using visual inputs from satellites or drones, and then automates the optimum installation design.[171]

The EqWater project of the Indian Institute of Science is deploying IoT, ML, predictive analytics, and big data to make water distribution fair and efficient in major Indian cities. EqWater has partnered with the Bangalore Water Supply Sewerage Board (BWSSB) to work out a geospatial map of water flow through southern Bengaluru by using data from the sensors in the water distribution network.[172] By combining sensor data with monthly water bills from consumers, demographic data from the census, and water level readings from reservoirs on the outskirts of the city, it creates a model to predict peak demand at different times and consequent gaps in the supply chain.[173]

Resource monitoring and detection

Companies are also adopting ML to monitor energy and water conditions. For example, Agua, a smart water management system, uses AI to measure water levels and analyse usage. It notifies users with information about their water usage through an app, which can also activate an automated valve that can be used to control the distribution of the water.[174]

There are instances of ML being considered to monitor equipment health. For instance, researchers at the Thapar Institute of Engineering have developed a programme that uses statistical and ML alternatives to enable real-time inspection of solar panels and keep a check on damage from weather, temperature, and UV exposure.[175] This predicts when the panels will require maintenance, to avoid deterioration in their performance.[176]

Another example is a prototype of an AI system, built by researchers at IIT Kanpur and the Indian Institute of Toxicology Research to assess the water quality of the Gomti river.[177] It uses water quality variables as parameters to predict dissolved oxygen and biological oxygen demand to assess the quality of water.

There are instances of ML being used to detect weather hazards, imbalances in the network, and theft. For instance, Tata Power Delhi Distribution (TPDDL) uses AI algorithms to detect abnormal usage on the grid and alert utilities companies.[178] Quenext, an AI lab, uses AI-based systems to monitor assets distributed across wide areas for potential weather hazard and imbalances in the network.

Challenges for adoption

Adoption of AI is concentrated amongst large utility companies such as Tata Power's theft detection or Adani Green Energy's use of Huawei's Smart PV Solution. [179] These AI-based systems are yet to witness deployment through state initiatives across cities and households. Although national-level strategies indicate state interest in incorporating AI into existing state utility systems, it might prove to be difficult as outstanding power bills and subsidies have put state governments under financial stress.[180] For example, distribution companies are split on smart metering due to high costs.[181]
The power sector in India is in dire need of an infrastructure upgrade. The existing electricity grid faces continuous power outages resulting in losses. However, modernising it to include AI is currently restricted by the limited investment abilities of distribution companies.[182]

Introducing AI into current systems of energy and water production at both the state and national levels, and even within the private sector, requires adequate technical expertise. This would require re-skilling and capacity building in using AI to produce utilities, and to ensure meeting the consumers' demand for better energy and water management which is increasingly being driven by awareness around renewable energy.[183] For example, the Smart Grid project is experiencing similar problems. It lacks dedicated and skilled manpower to manage and maintain multiple pilot projects, which could lead to delayed implementation of the technology.[184] The integration of AI systems by state and national initiatives is likely to be plagued by the same concerns.

Potential benefits

The energy sector has been looking for solutions to improve the planning of energy distribution, monitor assets, reduce aggregate technical and commercial losses, and increase profitability. AI can be used to meet some of these aims. It can assist in the forecasting of demand and supply of electricity, and weather conditions that could potentially impact it, to aid in planning. This ability to predict usage could also reduce reliance on other forms of non-renewable power, thereby reducing wastage, reaping benefits for sustainability and the environment.[185]

The increasing integration of applications and virtual assistants that rely on AI to help consumers monitor their energy consumption could optimise energy use. With energy and water management systems providing recommendations or allowing for automated scheduling, consumers could use their machines during periods when consumption is optimum.[186] For example, AI could suggest the right time to run a load in the washing machine based on when the electricity price is likely to be low. Grid Edge has developed a technology that allows firms to control the use of energy in their buildings by utilising low-demand and cheaper electricity periods.

This could provide companies with the opportunity to reduce the strain on the National Grid for a set price.[187]

According to a report published in 2015 by the Northeast Group, a smart infrastructure market intelligence firm, the power sector in India loses around $16.2 billion to theft every year.[188] Energy theft can be addressed with the use of ML applications. By analysing electricity meter data based on previous energy patterns, it can detect any irregular use.[189] Electrobas, a power utility company in Brazil, employed an anti-theft programme to find that 22% of all energy in Brazil was being siphoned off.[190]

Apart from theft, breaches on a larger scale such as on energy grids can result in loss of energy production and risks to infrastructure. AI could provide protection and ensure continuity of the infrastructure's operations.[191] This could be done by using real-time security monitoring to determine and track normal behaviour, and then flag irregular activities.[192]

AI systems could detect bursts or leaks by monitoring pressure and flow sensors in real-time to forecast possible equipment failure.[193] AI techniques like Artificial Neural Networks could also be used to analyse content in groundwater[194] and forecast groundwater reserves.[195] As with energy, AI platforms could be used to provide consumers with real-time information on their water consumption and offer solutions on reducing excessive usage. They could also help authorities understand water loss and work towards an efficient distribution network.[196]

Potential harm

Applications being developed to track and monitor levels of consumption in order to optimise usage, are reliant on real-time data of consumers. This enables companies to derive meta-data and information on the consumer's movements and behavioural patterns, which poses a threat to individual privacy. Inferences based on this data can also be misused if leaked or shared with third party vendors. There are also concerns about the lack of transparency of the data and of insights being shared.[197] This information could result in profiling or discriminatory practices against certain social groups through price discrimination or exclusion from access to utilities based on income levels, religion or caste.[198]

In a global survey by Siemens and the Ponemon Institute in 2019, more than 54% of utility companies stated that they expected at least one cyberattack on their operation technology within the next year.[199] Utilities in India have also been the target of malware and cyberattacks in the past.[200] The current state of security for critical infrastructure in the sector is lacking and makes it susceptible to attacks that would result in both a loss of data and a disruption to operations.[201] In addition, with older systems in place, patching vulnerabilities is both difficult and costly.[202] Failure in essential services such as utilities can have a cascading effect on other systems that are reliant on them and exacerbate the fallout.

6. Enterprise Solutions

A bulk of AI adoption across India is for enterprise solutions.[203] According to a PWC report, 72% of business decision makers believe that AI gives their business a competitive edge.[204] In its National Strategy for Artificial Intelligence, NITI Aayog has identified private enterprise as one of the three market segments for increased AI adoption. To accelerate adoption across these segments, NITI Aayog has recommended the establishment of a national artificial intelligence marketplace (NAIM), which will consist of a data marketplace, a data annotation marketplace, and a solutions marketplace. Enterprises are envisioned as a key stakeholder in the NAIM, where they will be able to both provide and seek solutions.[205]

A study conducted by the National Association of Software and Services Companies (NASSCOM), in association with Google and ICRIER suggests that the use of AI in enterprise solutions could increase India's GDP by 2.5% in the near future.[206]

There is a strong push from the government to make India a world leader in AI and to realise the economic benefits of AI. The role of AI within the enterprise sector is critical to the realisation of this vision, given that India is a rapidly growing market for AI-based business solutions.

Main AI-based interventions

We have identified 4 types of AI-based product interventions in the enterprise sector:

Data-driven insights for improved decision making

There are instances of AI systems being used to derive business intelligence, using different sources of data. Using analytics, these systems generate actionable insights that could help businesses make better decisions.

SynctacticAI has developed a platform for businesses that uses data science tools and algorithms to draw insights from the data sets of a business, both structured and unstructured. Several enterprises, such as Shriram Finance and ChefSocial, are using SynctacticAI's platform, which claims to increase operational efficiency by 30% and improve decision-making by over 50%.[207] Smarten has developed easy-to-use augmented analytics and data discovery tools in order to equip business users with the tools necessary to leverage analytics.

There are also instances of companies using computer vision to enable video analytics and gain insights from stores, both physical and digital, and also streamline manufacturing at factories.

Wesense.ai's retail sense tool uses footage from CCTV systems to generate insights for retail stores. It provides stores with data such as number of visitors, their demographics, parts of the store where visitors spend the most time, and how much attention is captured by ads. Deployed in 25 cities, their tool is being used by over 230 stores such as Lenskart, Xiaomi, Croma, and Dell, among others.[208]

Myntra uses AI-enabled analytics to predict shopper behaviour and to analyse fashion trends to decide what to sell on the platform. Using these analytics, Myntra also provides customers recommendations based on their purchase history.

Sparrosense's AI Supervisor focuses on using AI-powered video analytics for manufacturing. Using videos from CCTVs, the tool analyses the movements and actions of both machines and workers. It then uses these to predict and prevent delays in the manufacturing processes.

This tool has been deployed by many companies, including Vedanta and the Merino Group.[209]

Improved customer engagement and customer service

Chatbots, in some instances, are being used to improve customer engagement, answer commonly asked queries, and help customers discover information and navigate their digital platforms. For instance, Haptik helps build AI-powered conversational chatbots for companies to engage with customers and help in sales conversions, while also automating responses to commonly asked questions. Additionally, Haptik's feedback bot helps companies collect feedback from clients. Haptik also builds concierge bots that enable customers to accomplish tasks like booking tickets and entertainment bots that engage the customer through trivia and jokes. Haptik has deployed 105 solutions for companies such as Jio and Oyo Rooms, and has reached over 100 million consumers.[210]

Other solutions, such as auMina, are also being used to improve customer engagement and the customer service experience. auMina is a conversational analytics tool developed by Uniphore that analyses conversations between customers and company representatives. It provides companies with details such as customer sentiment, first-call resolution, and other customer relationship management metrics. It also helps gauge the real-intent of customers and provides company representatives with real-time assistance, which can help improve the customer service experience and also sales effectiveness.

PNBMetLife has developed a machine learning-powered customer service app, khUshi. Equipped with speech recognition abilities, it provides customers with information about their policies, answers their queries, and gives them customised prompts based on their activity. The application has been installed on over 1,00,000 devices.[211]

Process and task optimisation and automation

There are instances of enterprises using ML and robotic process automation (RPA) to automate task pipelines. For example, Soroco records how a task is done manually by the employees and uses machine learning to generate a programme for the task's RPA. JIFFY.ai, uses RPA, ML and AI to automate complex business processes including tests, across the software development lifecycle.

Companies such as Spotdraft are building NLP-based systems that help draft, review, and analyse contracts as well as remind users of important dates from within the contract.

In some instances, computer vision and ML systems are also helping companies automate user validation and onboarding. For instance, TrustCheckr processes user information to validate the user and check for fraudulent information or fake profiles.

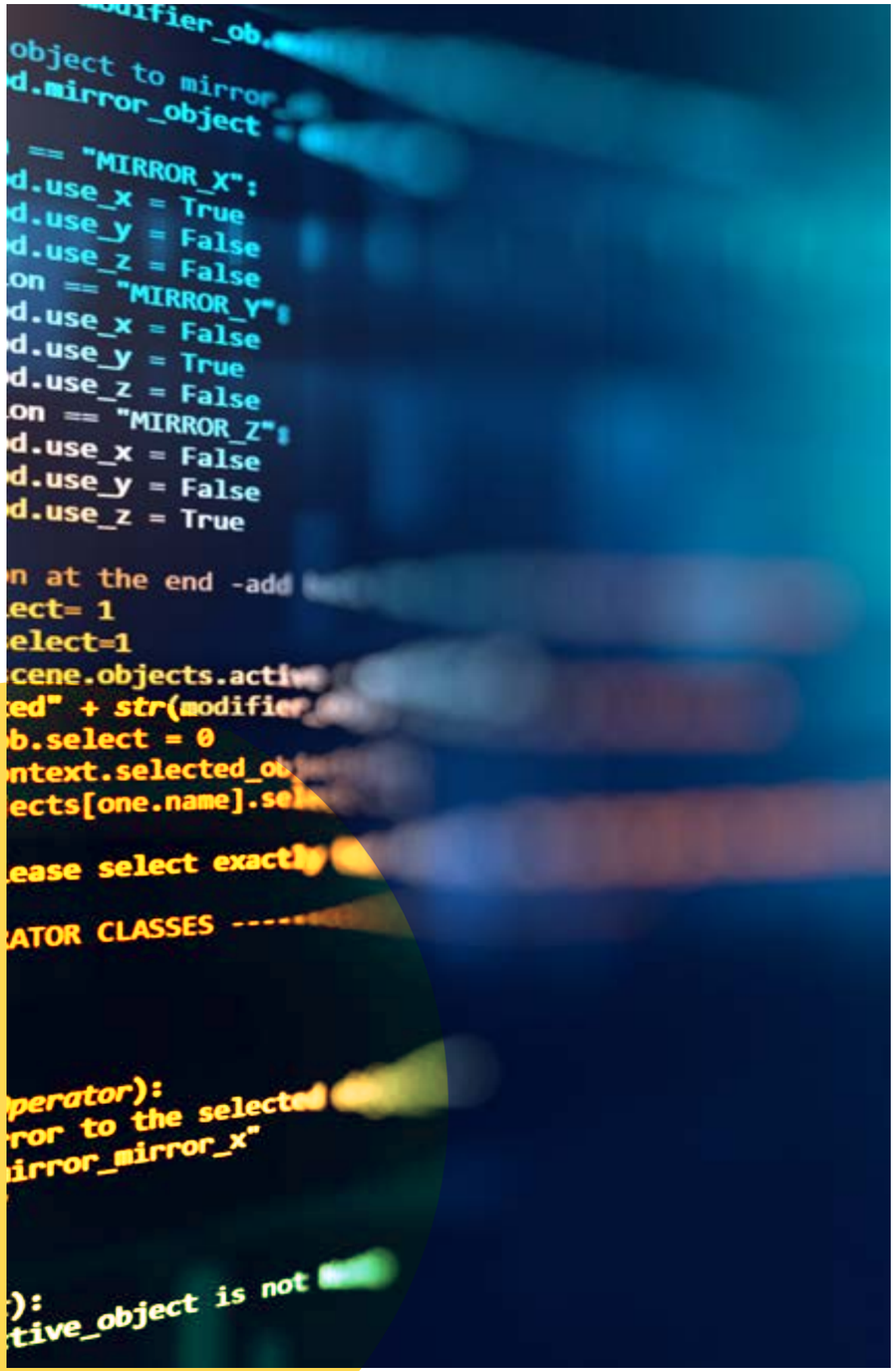
Some companies are using AI and ML to automate talent acquisition. Zwayam's talent acquisition suite uses RPA, ML, and AI to automate different levels of the talent acquisition process, from sourcing candidates and screening resumes to conducting assessments and onboarding new hires. Zwayam has automated the hiring process for over 58,000 jobs across over 10,000 companies.[212]

Personalisation

ML-based applications are also being used to mine user data for insights on user behaviour and preferences, to create user profiles. This information allows companies to send targeted advertisements and marketing content.

For instance, InMobi uses data to create user profiles, allowing companies to effectively plan marketing campaigns and target their advertisements. AbsolutData's NAVIK Marketing AI tool uses an AI-driven analytics engine to analyse customer behaviour and personalise recommendations. It also uses customer profiles and interactions with the brand to predict future behaviour. News reports indicate that Aegon Life Insurance has multiple projects using AI and ML, which, among other things, provide personalised consumer content.[213]

Companies like SensoVision are using image recognition to identify gender, age, and gestures of people when viewing advertisement boards to cull insights about viewer engagement.



Challenges for adoption

Most companies developing enterprise solutions prefer working with large companies, as they have more data, which allows for greater performance of AI models.[214] Therefore, in the enterprise sector, the gains of AI are reaped primarily by bigger companies that have large amounts of data, which make AI-based solutions easy to deploy. However, the ability of big companies to scale up their AI-based solutions is restricted by the low technological maturity of most entities in the external ecosystem. A joint study conducted by EY and NASSCOM found that 56% of survey respondents believed low external ecosystem maturity impedes the progress of their AI initiatives.[215] Other concerns that business leaders have around the state of technology and data include the low rate of digitisation, disparate or unstructured datasets, and the lack of adequate training data.[216] BFSI and retail enterprises have been leading AI adoption since data in these sectors is widely available and digitised for the most part.[217]

The study conducted by EY and NASSCOM also found that an inability to quantify the benefits of AI systems impedes adoption. The lack of explainability is another factor that holds back adoption. Businesses are reluctant to use automated decision-making systems for making critical decisions, because many of these systems do not explain the rationale behind the decisions.

For small and medium enterprises, the cost of technology, storage and infrastructural overhaul poses a challenge for adoption.[218] Smaller companies also have to incur huge costs of compliance with data privacy policies such as the General Data Protection Regulation (GDPR).[219]

Adoption is also impeded across the board by a talent shortage in the AI space. While more companies are working on AI-related projects, a recent study finds that there is still a lack of talent and many AI-related roles are filled by professionals from other backgrounds.[220] A joint study conducted by EY and NASSCOM found that 40% of business leaders saw the lack of talent as a key hurdle in implementing and scaling AI solutions.[221]

Data privacy and security are extremely critical in developing solutions for enterprises. The lack of secure data storage and processing architectures also impedes adoption across enterprises.[222] Further, there could be a trade-off between data security and usability, since the more secure the data, the slower their retrieval.[223]

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Potential benefits

Market research studies forecast the continued growth and widespread adoption of AI in this sector. Currently, the Indian enterprise market for AI is estimated to be $100 million, growing at 200-250% compound annual growth rate (CAGR).[224] AI-based enterprise solutions are particularly suited to India, given the market share of large conglomerates and the assets they hold.[225] Apart from increasing the efficiency of enterprises, the growth and widespread adoption of these solutions is also likely to contribute substantially to India's economic growth.[226]

ML applications for enterprises create new business intelligence and can improve product and service offerings. Studies indicate that there is a growing demand for enterprise-ready AI solutions, in core business applications such as Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM), but also in auxiliary processes such as customer support, recruitment, sales and marketing.[227] A joint study recently conducted by NASSCOM and EY found that 60% of business leaders surveyed by them believe AI will disrupt their businesses within the next two to three years.[228]

The use of AI and ML-based solutions is also likely to make products and services more accessible. Indian Farmers Fertiliser Cooperative (IFFCO), for example, is using an AI-powered chatbot developed by Oracle to help farmers acquire fertilisers. IFFCO plans to make the chatbot multilingual, making it accessible to around five crore farmers and thirty five thousand cooperative societies across the country.[229]

Potential harm

Currently, big gains are being experienced by large organisations that have large amounts of data. This could give these organisations a market advantage, thereby lowering healthy competition in the market. Since AI-based solutions increase efficiency and reduce costs, large organisations that are currently adopting these solutions could be gaining a significant advantage over smaller companies which have not achieved the scale needed to adopt these AI applications.

The use of AI to profile and predict consumer behaviour could infringe on privacy rights. There are 1 billion surveillance cameras likely to be in operation across the globe by 2021.[230] Stores are using them to gather more information about customers[231] as well as monitor their employee performance.[232] As celebrated writer Shoshana Zuboff notes, constant monitoring of an individual's online activities also reduces them to mere data points, with information about them being used, not only to improve services delivered to them, but also for targeted advertising and making predictions about their future behaviour.[233]

The efficiency benefits of AI have to be balanced against the impact it is likely to have on labour. Efficiency enabled through ML applications may result in job displacement, particularly for entry level tasks that involve routine and repetitive tasks. A survey conducted by the job and recruitment portal, Shine, found that up to one-third of existing jobs across sectors are likely to be automated by 2022.[234]

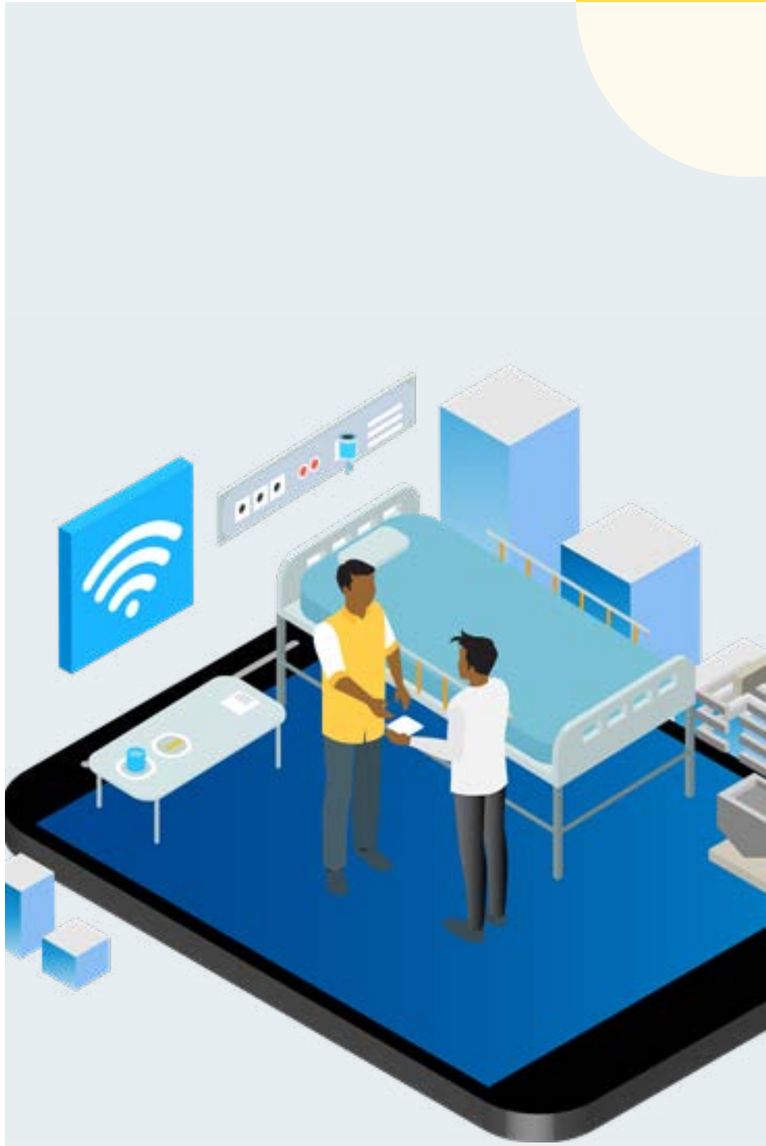
As companies gather more and more consumer data for business analytics, there is a risk that these companies may become targets of cyberattacks and data breaches.[235] This could compromise the data security of both individuals and companies.

7. Healthcare

India is witnessing a rapid growth in the number of tech start-ups and investments in the healthcare sector. Currently, there are about 3,225 digital health-tech start-ups, providing a range of digital and, in some instances, AI solutions.[236] Recent reports also suggest that investments in health-tech startups are rising steadily, with $163 million and $343 million recorded in 2016 and 2017 respectively.[237]

The application of AI in healthcare is a key priority for the Indian government, with stakeholders such as NITI Aayog and FICCI calling for the greater integration of AI in healthcare.[238] Efforts to digitise the health system are also under way.[239] The government has released a blueprint for the creation of a central repository of health data, the National Health Stack (NHS). The National Health Stack would not only incorporate AI in its functioning (through the health data analytics platform), but could also act as a foundational layer upon which other AI-based healthcare interventions can be built.[240]

While most AI applications for healthcare are being developed by private companies, there are instances of collaboration between government and private sector in this space. For example, NITI Aayog is working with Microsoft and Forus Health to develop a pilot for the early detection of diabetic retinopathy.[241] The Government of Maharashtra has signed a Memorandum of Understanding with NITI Aayog and the Wadhwani AI group to launch the International Centre for Transformational Artificial Intelligence (ICTAI), focusing on rural healthcare.[242] The Telangana government has adopted Microsoft Intelligent Network for Eyecare, which was developed in partnership with the Hyderabad-based LV Prasad Eye Institute.[243] More recently, the government's National Health Authority (NHA) has partnered with SAS, to incorporate AI-based processing of insurance claims for the Ayushman Bharat Scheme.[244] In 2020, the Union Health Ministry also announced plans to explore the use of AI applications in public health, and fields such as cancer detection and radiology.[245]



Main AI-based interventions

We have identified 6 types of AI-based products and services in the sector.

Disease detection

ML applications are being used in several instances to aid doctors in the early detection of diseases and pathologies such as breast cancer, diabetic retinopathy, malaria and tuberculosis. For example, Niramai has developed a thermal imaging-based AI solution, Thermalytix, to detect early signs of breast cancer. Some of these tools also provide for triage i.e., the process of determining and allocating degrees of urgency to wounds or illnesses in order to prioritise the order of treatment of patients, when there is a large number of people requiring medical attention at the same time. For example, Qure.ai's product, qER which is an AI-based CT scan tool, is used to prioritise patients with the severest conditions.[246]

There are also several examples of partnerships between technology companies, hospitals and government institutions. Google has piloted its diabetic retinopathy detection tool in partnership with Aravind Eye Hospital in Madurai, Narayana Nethralaya in Chennai and Sankara Nethralaya in Bengaluru.[247] NITI Aayog is also running a pilot project at the LV Prasad Eye Institute in partnership with Microsoft, to develop AI-powered diabetic retinopathy detection systems.

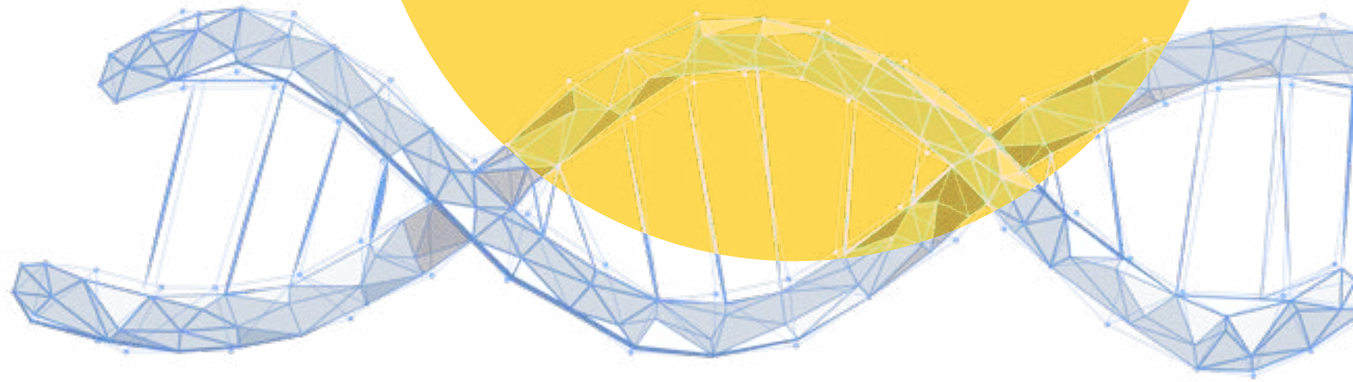
Several AI companies have chatbots to provide healthcare information. These also act as first-level symptom screeners and checkers. For example, chatbots such as Wysa and Woebot, have been developed to allow users to keep track of their mental health, share symptoms and seek further medical help from professionals through these platforms. Telemedicine platforms such as Onlidoc[248] and Practo[249] are using ML to identify and match users with medical specialists, based on their symptoms.

Disease forecasting

There are instances of ML algorithms being developed to predict the spread of diseases at a population level as well as to calculate the probability that an individual may contract a condition. In 2018, the Central TB Division in India signed a Memorandum of Understanding (MoU) with Wadhwani Institute for Artificial Intelligence to develop, test and deploy AI solutions for vulnerability and hot-spot mapping. The mandate of the MoU is also to develop novel methods of screening and diagnostics; to enable decision support for care-givers; and to support the Revised National Tuberculosis Control Program (RNTCP) in the adoption of other AI technologies.[250]

Personalised healthcare

In some instances, ML algorithms are being used to deliver personalised treatment plans for patients. For example, MitraBiotech is using ML to understand cancer drug interactions at a cellular level, in order to recommend personalised cancer drug treatments. Similarly, Healthi, a digital health and wellness startup, is using predictive analytics, personalisation algorithms and machine learning to deliver personalised health suggestions. Microsoft AI has partnered with Apollo Hospitals to build an AI-centric cardiology network. The company will use AI models to predict heart disease risks in patients and support physicians with targeted treatment plans.[251]



AI in remote health monitoring

There are some instances of ML algorithms being applied to remote health monitoring systems for real time data analysis and to generate predictive trends regarding a patient's vitals. Remote patient monitoring systems use a network of sensors to keep track of a patient's vitals such as heart rate and oxygen levels; the addition of ML into this process allows the systems to also predict the potential deterioration of a patient's vitals. A few companies such as StasisLabs and Citta.ai are integrating such AI-based functionalities into their remote health monitoring systems. According to news reports, the Stasis patient monitoring solution is being used across 20 hospitals in India, including Fortis, Ramaiah Hospitals, Columbia Asia, HCG, and Cloudnine, with more than 500 doctors using the Stasis App to remotely monitor their patients.[252] AI-based remote health monitoring tools also come in different sizes, from home monitoring portable devices to wearable sensors. For example, RayIoT has developed portable baby monitoring devices which can be used at home or in hospital wards. Ten3T has developed 'Cicer', a wearable smart patch, that monitors health indicators like pulse, respiration, posture, fall, and temperature.

Back-end process optimisation

There are several instances of AI being used across operational pipelines in healthcare institutions. In some cases, ML algorithms are used to predict hospital stay durations and patient churn-rates to optimise the usage of beds in the hospital. Wadhwani AI has developed an AI solution to help identify missing TB cases. It will allow health workers to prioritise TB patients and assess the degree of risk of their drop-off from treatment. Onlidoc also uses Optical Character Reader (OCR) systems to scan prescriptions, check the availability of medicines in the inventory and help dispatch the medicines.

ML is being used in health insurance services for claim processing and detecting claims fraud. For example, ICICI Lombard launched an ML system to automate health insurance claims for a number of procedures.[253] Acko Insurance is using ML to automatically price insurance products by scraping information about individuals from different online platforms.[254]

Medical R&D and training

A few companies like Elucidata and Vingyani are using deep learning techniques for drug discovery and advanced genomics. ML learning for drug discovery is primarily used to make sense of large and complex datasets in order to identify clinically meaningful data.[255]

There are some instances of ML-based simulators being used for medical training. These systems provide an artificially simulated environment for surgical practice. MedAchievers and Labindia Healthcare opened their first surgery simulator centre in Delhi-NCR in 2018.[256] The Apex Heart Institute (Ahmedabad) and Amrita Institute of Medical Sciences (Kochi) are using AI-assisted robotics that can guide the surgeon's instrument during a procedure.

Challenges for adoption

The healthcare sector in India has been slow to adopt digital technologies and digitisation practices. Some large corporate hospitals such as Max Health, Apollo, Sankara Nethralaya and Fortis, have integrated ICT systems like EHRs that deal with registration and billing as well as laboratory and clinical data. However, most public hospitals and dispensaries in India have very little ICT infrastructure.[257]

Even when hospitals have digitised health records, these are rarely shared with other hospitals.[258] This can impede the development of AI applications and interoperability of systems for users. Even though the central government has made efforts towards the digitisation of health records, Kerala is the only state in India which has successfully collected and stored electronic health records of 2.58 crore people through its 'eHealth project'.[259]

Further challenges to adoption are caused by the lack of trust in AI-based systems due to the black box nature of the technology and the lack of clarity on liability of medical professionals in the case of AI-based errors.[260] The lack of adequate standardisation measures and regulatory oversight of AI-based medical interventions could pose a hurdle for adoption. The Medical Devices Rules, 2017 (MDR) has been amended to include software,[261] but it is only the first step in setting standards for the use of AI-based applications in healthcare.

Government spending on healthcare is already one of the lowest in the world. In 2016-2017 only 1.4% of the GDP was allocated to healthcare, compared to the global average of 6%.[262] Private hospitals and medical establishments are the key providers of quality healthcare in India, and more than 71% of healthcare expenditure is borne privately by individuals. As a result, expensive AI-based solutions may not be easily adopted by consumers and healthcare providers.

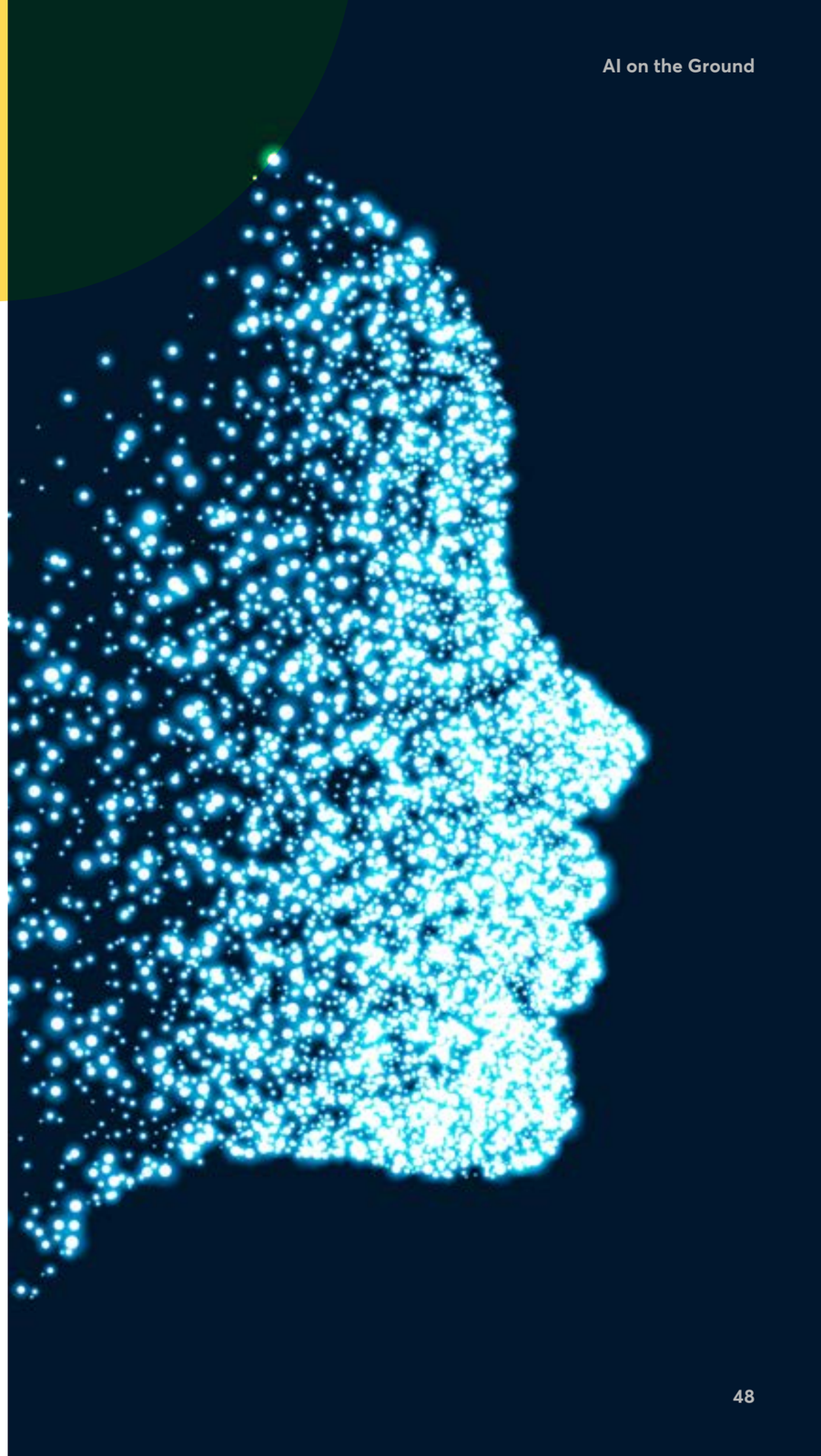
Potential benefits

Several ML applications which have been developed to detect specific diseases such as breast cancer and diabetic retinopathy are not only at par with human-level diagnosis but can also, in some instances, detect diseases more accurately and earlier than humans or other existing technology. For example, Niramai's Thermalytix was found to perform better than traditional mammography, when tested in three cancer hospitals in India.[263] Pairing ML-based solutions with low-cost hardware solutions (e.g., mobile phones) or offline access, combined with government funding can improve access to healthcare in tier III cities and rural areas. For example, all Bruhat Bengaluru Mahanagara Palike (BBMP) hospitals in Bengaluru are providing free breast cancer screening for underprivileged women.[264]

The use of these systems could augment the baseline skills of medical professionals. For example, Google's study on the accuracy of its diabetic retinopathy algorithm showed that using the algorithm improved the accuracy of retina specialists above that of the unassisted specialist or the AI model alone.[265] ML for disease detection can also help achieve public health targets in India. For instance, early detection is a critical part of cancer care, but though India registers almost 1 million new cancer cases every year, good quality pathology services are not easily accessible. There are only 2,000 pathologists experienced in oncology, and less than 500 oncopathology experts in the country.[266]

ML tools which provide first level screening for disease detection, could also reduce resource burden and proactively identify cases which require medical assistance. Process optimisation applications, such as AI-based data analytics for triage can also reduce workloads for doctors and nursing staff and assist providers with logistics and planning. The use of AI to monitor critical care patients at Max Hospital in Delhi has, reportedly, brought down costs to patients by 30%.[267]

ML learning algorithms can be used to draw insights from the vast amounts of data generated through robotic automation processes and EHR (electronic health record) systems. For example, EHR records can be combined with an individual's medical history, as well as biogenetic information to personalise treatment plans, and provide an accurate prognosis. ML tools could also shorten the innovation time for drug discovery and information retrieval. The use of AI for assistive surgery and medical training could reduce complications in surgeries and augment traditional modes of learning.



Potential harm

If not trained properly or trained with unrepresentative datasets, AI systems can deliver inaccurate decisions or reproduce biases. For example, researchers in the U.S. have pointed out that the use of AI for skin cancer detection can widen racial disparities. The particular algorithm under study was found to be more effective at detecting melanoma in white skin than black. However, even though melanoma is rarer in individuals with black skin, those with black skin have higher rates of mortality.[268]

Since ML systems are dependent on historical data, they reflect historical trends around access to medical services. This could mean that AI systems do not reflect the needs of certain parts of the population. In some cases this could result in misdiagnosis, or under-attention to particular kinds of medical ailments. For example, historical datasets could reflect lower disease incidence for females. However, this could be due to factors such as lower prioritisation and expenditure on women's health within the family as compared to men's, leading to under-reporting.[269] The use of AI in such a scenario could widen the existing gender disparities in accessing healthcare in India.

ML based systems developed for different geographies may not be usable for different contexts. This could also potentially result in a misdiagnosis. In cases where companies use readymade AI-based solutions developed for other geographies or inaccurate datasets, there is a risk of misdiagnosis. For example, internal documents on IBM Watson show that the tools could have only limited accuracy, as the system is trained on data from American patients which do not translate to a new context.[270] Similarly, when Google's diabetic retinopathy tool was tested in clinics in Thailand, the system rejected many retinal images as they did not match the quality of images produced in lab conditions in the US. Thus, even though the tool had a 90% accuracy for detecting diabetic retinopathy under lab conditions, it ended up complicating and extending the screening process on the ground.

The erosion of privacy through disclosure of sensitive health information is a key concern. This is exacerbated by instances of cybersecurity breaches in hospitals as well as government databases in India, raising concerns regarding the security of private health. In 2019, the Department of Medical, Health and Family Welfare of a north Indian state left a database connected to the internet without a password, exposing the medical records of more than 12.5 million pregnant women.[271] Similarly, in 2019, cyber security firm FireEye reported that cyber criminals hacked an Indian healthcare website, stealing 68 lakh records comprising information on patients and doctors.[272] Even with anonymised data, the risks of re-identification persist.[273]

There is also a risk of exclusion or discrimination if health data is linked to other data sets. The growing market for data could lead to unethical practices of data mining and data sharing. For example, without regulatory frameworks on data sharing, well-being and lifestyle apps that track users' health habits and information could share this data with insurance companies, which could in turn create a hike in premiums. Several insurance companies in the US are known to use data from fit-bits and GPS location to continually monitor risk in real time and create behaviour profiles of customers.[274]

8. Policing

Several Indian states are moving towards the adoption of ML-based interventions at various levels of police work. As early as 2015, the Delhi Police announced plans to use predictive policing through its Crime Mapping, Analytics and Predictive System (CMAPS), a software that accesses real-time data from the city police's helpline to identify criminal hotspots in the city.[275] In Punjab, the police are using an application called Punjab Artificial Intelligence System (PAIS), to match faces to existing criminal databases and access information on prior criminal history and gang affiliations.[276] Assam has announced plans to set up an AI-powered data analysis facility for predictive policing, under their broader Cyber-dome project.[277]

The government is also in the process of integrating various citizen databases, which could in the future be used for AI-based analytics and intelligence reports. In 2009, the Ministry of Home Affairs, started setting up the national intelligence grid (NATGRID), to link multiple public and private databases such as airlines, telecommunication and banking and make these data available to intelligence agencies.[278] According to the Ministry of Home Affairs, NATGRID is expected to be operational by December 2020.[279]

In 2009, the government also set up the Crime and Criminal Tracking Network and Systems (CCTNS), which is a nationwide online tracking system that integrates information from 14,000 police stations across the country.[280] In 2019, the NCRB invited tenders for the creation of an automated facial recognition system, to create a national-level searchable platform of facial images.[281] Very little is known about the scale or operationality of these systems as major exceptions are made for law enforcement agencies under the Right to Information (RTI) Act.[282]

Main AI-based interventions

We have identified 4 types of AI-based products and services in this sector.

Real-time monitoring and crime detection

Computer vision is being utilised by several Indian states, including Andhra Pradesh, Delhi, Karnataka, Gujarat and Telangana, to automatically identify people, and detect violations of the law in public places and institutions.[283] Companies such as Staqu, Innefu Labs and FaceTagr have rolled out various AI-based systems for facial recognition, object and character detection and real-time data analysis. Staqu has developed several AI-based products for policing, which include advanced image analysis, a language and text-independent speaker identification engine, facial recognition and text processing. For instance, JARVIS (Joint AI Research for Video Instances and Streams), a real-time video analytics platform developed by Staqu, provides detection of acts of violence, prison breaches, or unauthorised access in real time and alerts the authorities.[284] It has been installed in 70 prisons in Uttar Pradesh, where it analyses feeds from 700 cameras installed inside prisons. According to news reports, Staqu is currently working with at least 8 different state police departments in India.[285]

There are several other instances of AI-based facial recognition and computer vision systems being used in public places for a range of purposes, from crowd monitoring, to finding missing children and monitoring traffic violations. In 2018 Staqu also piloted one of its systems with the Rajasthan police department. It is called ABHED (Artificial Intelligence Based Human Efface Detection), and allows for real-time data analysis and facial recognition. The software has been paired with smart-glass by Sony and Epson to take inputs in real-time from what the person is seeing and deliver results straight to the glass.[286] Similarly, police in Kerala and Delhi, amongst others, have used facial recognition technology on crowds to detect individuals with open warrants and criminal records.[287]

AI-based cameras have been installed at several intersections and traffic junctions in cities such as Bangalore and Hyderabad to automatically spot traffic violations, identify the violators and generate challans. The Surat Police is using an American company, NEC's proprietary NeoFace technology for facial recognition, and vehicle number plate recognition to track persons of interest.[288]

The Karnataka Railway Protection Force (RPF) has deployed a facial recognition system developed by Facetagr to find missing children. It verifies photographs from different databases against those in missing persons files.[289] This application, reportedly, will be integrated with the Khoya Paya website of the Ministry of Women and Child Development which has a database of 3.5 lakh missing children.[290] According to the Delhi police, they were able to identify 3,000 missing children within the first four days of piloting the system.

Deterrence and pre-emptive policing

There are some instances of the police using ML-based data analytics to generate statistical insights on crime patterns and criminal activity hotspots for the purpose of predictive policing. These systems use a combination of historical crime data and location data to predict the probability of crimes in specific locations. For instance, ISRO has built CMAPS to be deployed by the Delhi Police. The CMAPS system uses real-time data from Delhi

Police's Dial 100 helpline and ISRO's satellite imagery, to spatially locate calls. It visualises them as cluster maps to identify crime hot spots.[291] Reports suggest that Telangana, in collaboration with IIIT Hyderabad, is building an ML-based system to identify vehicles that are more likely to violate traffic regulations, based on their history of challans.[292]

The police are also using ML systems for NLP to identify online content that signals criminal activities or possible national security threats. Security agencies have been using the ML-based NLP system, NETRA, developed by the Centre for Artificial Intelligence and Robotics (CAIR), to capture suspicious voice traffic passing through software such as Skype or Google Talk, as well as tweets, status updates, emails, instant messaging transcripts, internet calls, blogs and forums.[293] The Advanced Application for Social Media Analytics (AASMA) developed by IIIT-D and MEITY has used NLP and machine learning to scrape social media feed and conduct sentiment analysis on the content in order to detect possible threats to law and order and to allow the police to take pre-emptive action or identify suspects.[294] According to reports, more than 40 state and central government departments had deployed the tool by April 2017 and another 75 had requested its installation at the time.[295]

Internal efficiency management and checks

In some instances, police records are being digitised with the help of OCR. The digitised records allow for the retrieval of crime records and information in real time during verification at police checkpoints and investigations. They also enable the police to easily register and search for criminals using facial recognition technologies. The ABHED app developed by Staqu also helped police officers to digitise records.[296] Data analytics offered by AI-based platforms has improved internal efficiency and management. For instance, the PAIS system adopted by the police in Punjab and Uttar Pradesh, Telangana, Bihar and Rajasthan creates detailed profiles of previously convicted persons and provides information on an individual's biometric data and gang affiliations using a database of over 90,000 individuals. The system allows for the integration of data from different sources such as the CCTNS.[297]

Public facing police interventions

The police are also employing AI systems as aids in interacting with the public. The Kerala police introduced a robot named KP-Bot, deployed at the front office at the police headquarters.[298] The bot currently has limited capabilities; it receives visitors, records complaints, and directs them to different places in the police station as and when required. This bot is currently a pilot, and there are plans to introduce more of these at stations and at heavy traffic points in the city. There are also plans to equip these bots with metal and gas detectors and thermal imaging.[299]

Several Indian cities such as Delhi[300], Mumbai[301], Bangalore[302] and Lucknow[303] are procuring AI-based traffic management systems to automate traffic flow management. They could modify signal timings and provide real-time information about traffic conditions.

Challenges for adoption

Interviewees noted that adoption capacities are not uniform across states and departments.[304] There is a lack of proper ICT and digital infrastructure across different states. 31% respondents from West Bengal and 28% respondents from Assam said that a functional computer was never available at their police station/workplace.[305]

Even departments that have experimented with different AI tools, have had trouble moving out of the pilot stage and scaling up these technologies, either due to a lack of funds or because of internal bureaucratic practices.[306] For instance, according to the Bangalore City Traffic Police, while it is often reported that AI-powered traffic signals have been deployed at scale, only about 30 of the 1,400 traffic signals are powered by AI.[307]

Similarly, interviewees said that much of the historical data in the form of police records are not in readily usable formats for AI. Thus, only a small percentage of the data is currently being used to inform policing.[308] The lack of accuracy of algorithms is also a challenge. According to our interviewees, while technology companies approach police departments with plenty of promises and solutions, most of them are unable to deliver in terms of quality and performance of the technology. [309] The facial recognition systems deployed by the Delhi Police to find missing children is reported to have had an accuracy rate of a mere 2%.[310]

Potential benefits

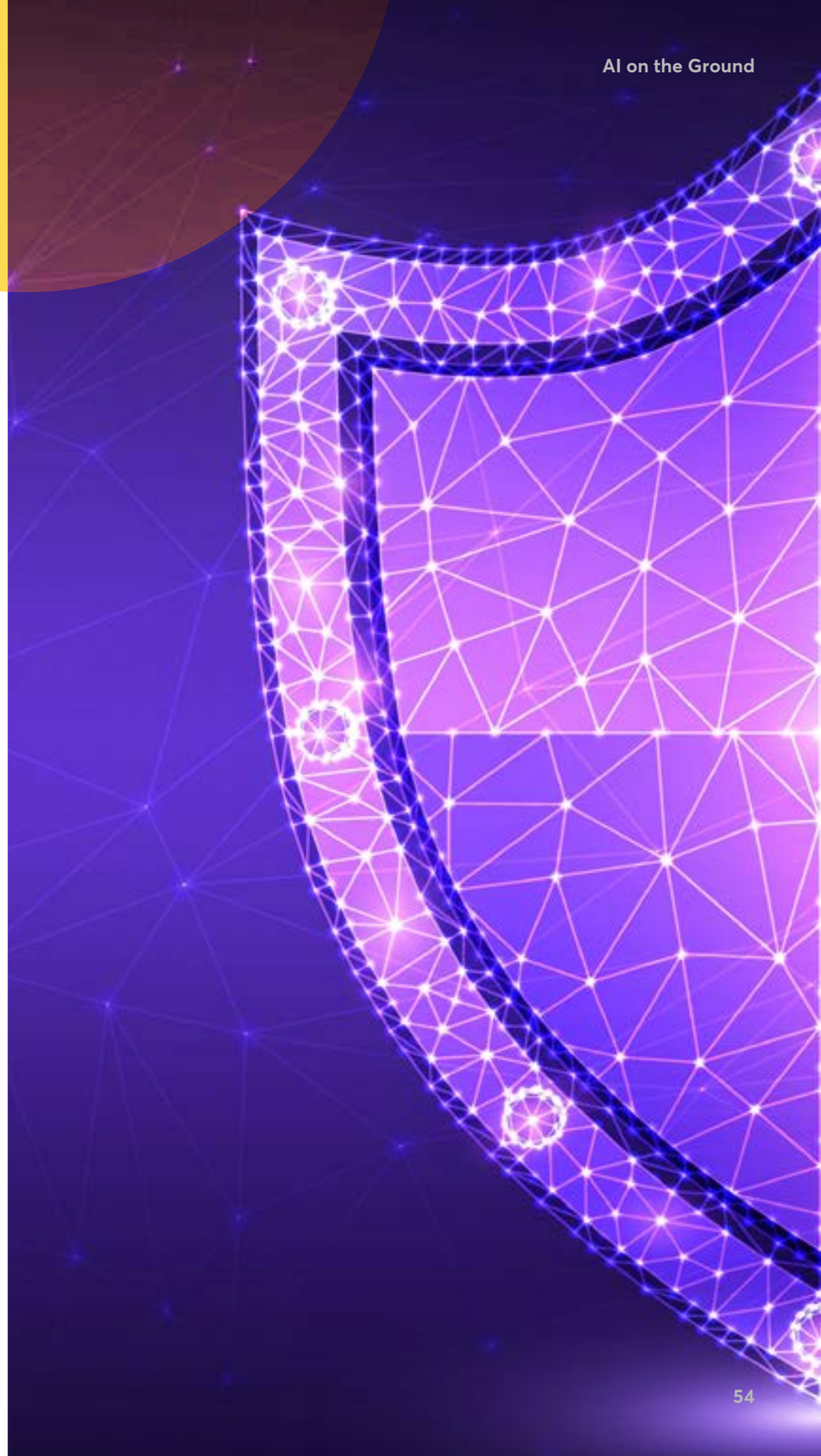
The use of ML platforms which provide easy access to information such as criminal history and gang affiliations could improve the efficiency of crime investigation. These platforms also widen the scope of identifying criminals through facial recognition and voice identification. Police officials we interviewed also suggest that the digitisation of police records could enable better coordination between different police departments and states.

Interviewees said that the use of ML will enable the police to manage the burden of work by automating mundane and repetitive tasks (such as filing for lost passport documents), and manually generating challans. According to the Bureau of Police Research and Development (BPRD), the use of AI could streamline police paperwork by automating and systematizing filing.[311] Using AI to improve internal efficiency and management would also reduce the workload of police personnel, 44% of whom work 14+ hours daily on an average, without added pay.[312]

The use of AI for traffic monitoring and crime prediction could compensate for the lack of personnel, (we have 148 police persons per 100,000 people; the United Nations' recommendation is 222)[313], by enabling efficient deployment of police patrols and reducing turnaround time on criminal activity.

Interviewees also suggested that ML-based applications would enable the police to adopt proactive police measures[314] and widen the scope of police work by allowing them to focus on preventative measures such as deterring crimes, creating a sense of safety and security within the community.[315]

We spoke to a police officer who provided an example of this. The Punjab police used AI to identify a drug-peddling hotspot. The identified area was then populated with food stalls to attract public activity, thus making the area less conducive to drug peddling. In traffic policing too these systems could identify areas of high violations and accidents so that the police could take proactive measures for prevention.



Potential harm

The primary data sources for AI systems in policing are historical data from police records, crime reports, CCTV footage or open source data sets (e.g., NCRB, opengov). Crime prediction on the basis of historical data could entrench bias and discrimination against specific communities, especially those that have historically been subject to discrimination and abuse of power. For instance, while Muslims, Dalits and tribals account for 39% of the overall population, they represent 55% of the population in jails.[316]

Given longstanding concerns around caste, religion and racial differences in policing, there is considerable danger that algorithms not only repeat but cement existing inequalities, leading to disparate impact on communities. Case studies from the US government's use of predictive policing and sentencing algorithms show the nature of disparate impact such algorithms can have on communities. In Propublica's study of Northpointe's criminal recidivism-risk scoring algorithm, it was found that black defendants who did not recidivate over a two-year period were nearly twice as likely to be misclassified as higher risk compared to their white counterparts (45% vs. 23%).[317]

Many AI systems often function as black boxes i.e., their inner workings cannot be completely interpreted, which makes it difficult to know how an algorithm has arrived at a particular decision or output. This lack of explainability and accountability inherent in black box AI models, could reduce public trust in institutions. For example, in the case of recidivism-scoring algorithms, if a user does not know why an individual has been categorised as high risk, it will be difficult to trust the system. Undetected errors in the system, such as misrecognition of license plate numbers, could also lead to wrongful prosecution.

The centralisation of data bases, clubbed together with real-time monitoring (be it social media or public spaces) using AI, could threaten individual privacy as well as lead to self-censorship and targeting. For example, in China, the pervasive use of AI-based surveillance systems and facial recognition technology to track and surveil Uighur Muslims, has led to the creation of what has been termed the 'world's largest open air digital prison'.[318] The use of AI-based surveillance cameras at traffic signals and other public places, in the absence of updated surveillance laws and adequate data protection could lead to greater surveillance. Further, without appropriate transparency laws, the extent of surveillance will remain unknown and public deliberation over it will be difficult.

An over reliance on AI systems which are easy to use, could reinforce over-policing. A study on Predpol, a predictive policing software provider in the US, showed that the algorithms in its crime hotspot mapping tool created a "feedback loop" that led to officers being repeatedly sent to certain neighbourhoods – typically ones with a high number of racial minorities – regardless of the true crime rate in that area.[319]

The creation of integrated information architectures at different scales widens cyber vulnerabilities by multiplying the points of exposure and surface of attack. In 2019, a ransomware attack infected the majority of North Carolina's government computers and locked all of the city's files after the ransomware was first noticed on a police department computer.[320] Several other US cities such as Atlanta, Baltimore faced cyber attacks on government-run systems, leading to huge recovery costs. According to a report by Subex, a cybersecurity firm in Bangalore, alongside the US, India was one of the most cyber attacked countries in the world in 2019.[321]

9. Public Tech

Government and civil society organisations use digital technologies, including those that use AI, to improve delivery of services and citizen engagement. For this chapter we have clubbed together these Gov-Tech and Civic-Tech applications as Public Tech. Public Tech covers a range of outputs, from optimising processes and improving service delivery to revamping information dissemination systems and upgrading grievance redressal mechanisms.

Governments across the world are starting to adopt ML-based applications to improve service delivery and civic engagement.[322] In India, there is a growing digitisation of government functions and services, along with many e-governance initiatives.[323] A recent study carried out to understand the adoption of AI in the public sector found that India and the US are the most active countries.[324] India's National Strategy for Artificial Intelligence envisions the government using AI-powered solutions to optimise internal processes, improve the delivery of services, reduce human discretion, and eliminate middlemen.[325] NITI Aayog has also announced plans to develop an AI-readiness index which will rank states on their capacity to adopt AI for the delivery of public services.[326]

Several government departments in India are now aiming to adopt ML-based applications for both service delivery and internal efficiency. For example, the Ministry of Housing and Urban Affairs (MoHUA) has reportedly directed the Central Public Works Department (CPWD) to use AI to identify any irregularities in accounting and contracts.[327] The India Meteorological Department (IMD) is planning to use artificial intelligence in weather forecasting.[328] During the 2020 Union Budget speech, the Finance Minister announced potential applications of AI in disease detection and pre-emption as part of the Pradhan Mantri Jan Arogya Yojana (PM-JAY).[329] The government has also started using ML models for fraud detection in the Ayushman Bharat initiative.[330]

Civil society organisations are also using AI-based solutions to improve citizen-state engagement, increase civic participation, and solve persistent civic problems. According to a report by CIIE. CO, VillageCapital, and Omidyar Network India, there are over 450 civic tech startups operating in India.[331] The civic tech sector has also reportedly seen an investment of over $100 million between 2016 and 2019.[332]

Main AI-based interventions

We have identified 2 types of AI-based product interventions for public tech.

Citizen Engagement

Chatbots for citizen engagement are used by a number of ministries and government departments. The Indian Railways has launched a text and voice-enabled conversational chatbot, Ask Disha, on the Indian Railway Catering and Tourism Corporation (IRCTC) website. This ML and NLP-powered conversational chatbot was developed by CoRover. Individuals can use the multilingual chatbot to obtain information regarding train schedules and other services offered by IRCTC.[333] The chatbot reportedly responds to over 1,50,000 queries daily, with 90% accuracy. It is also reported that customer satisfaction has increased by 70%, with more than 85% of users stating they are happy with the chatbot's services.[334] Floatbot, another startup that develops conversational AI platforms, has developed chatbots for the Rajkot and Pune municipal corporations. Apart from providing information, these chatbots allow individuals to apply for birth and death certificates, pay taxes, and file complaints.[335]

Startups and civil society organisations have also deployed AI-based interventions to disseminate information and engage with citizens. CoRover has developed an application, Ask Sarkar - *Pakki Jankari*, which uses ML and NLP to provide individuals with authentic information about government schemes, benefits, and policies. It supports over twelve Indian language, as well as English. The co-founder claims that the application has over 7 lakh active users.[336]

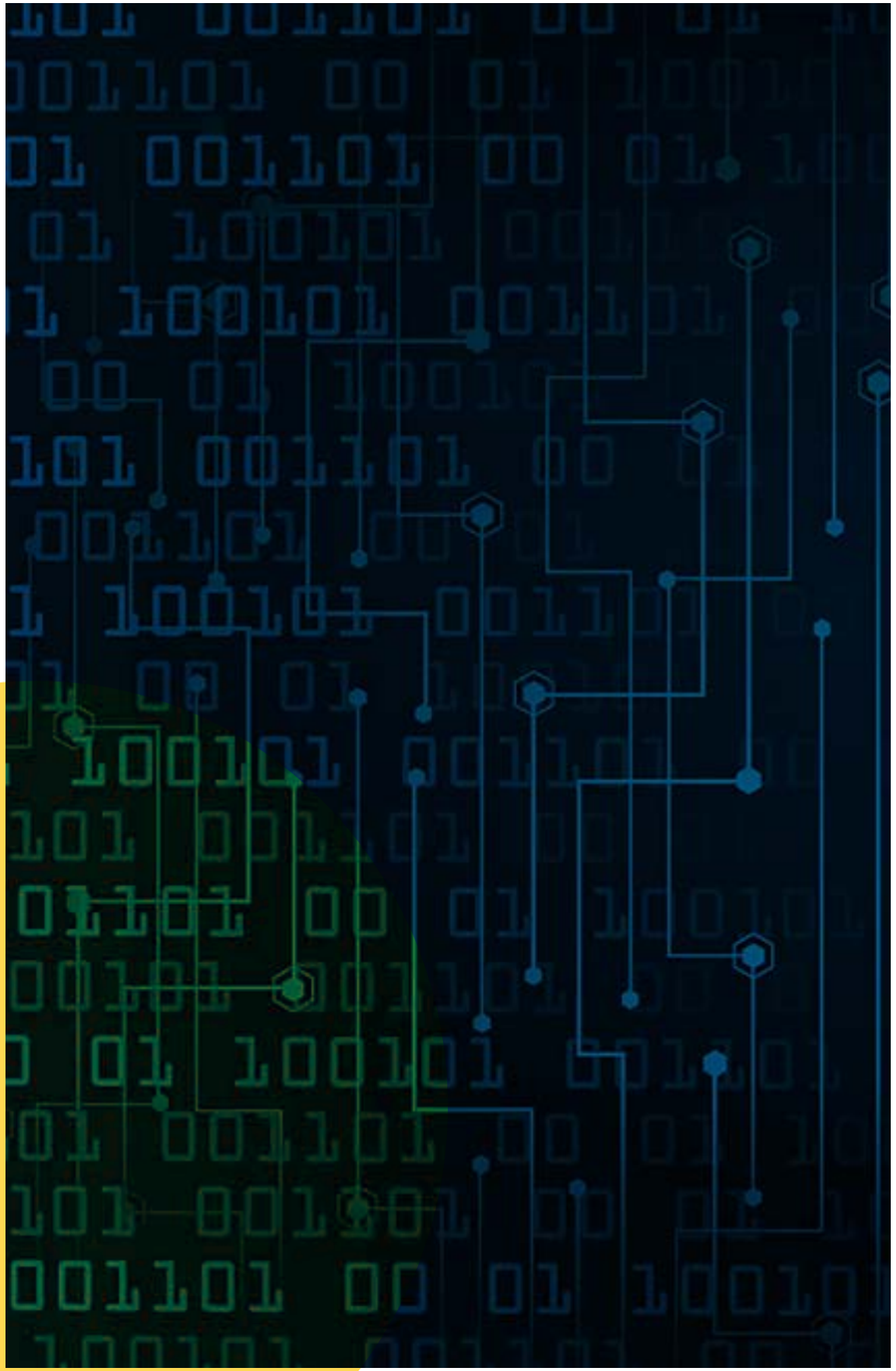
Other organisations, such as Civis and Nyaaya, are using NLP text classification and language translations. Civis and Nyaaya make legislations and laws publicly accessible and easily consumable for citizens. Civis enables citizen engagement by encouraging feedback on policy decisions. Nyaaya interprets and demystifies Indian laws to bolster a rights-based action approach.[337]

Optimisation of Processes and Services

The Ministry of Civil Aviation has launched the Digi Yatra programme where airports are being prepared to use facial recognition-based biometrics for paperless authentication.[338] The Telangana Government has implemented a system for Real Time Digital Authentication of Identity (RTDAI) that uses ML to verify identity. It is currently being used to authenticate the identity of pensioners. Individuals have to upload their photo through an application. The RTDAI system then instantly cross-checks with government records to ascertain whether the individual is a legitimate pensioner. The government claims that the system has a success rate of 93%, and with time, as the system learns, the success rate could reach between 96 and 98%.[339]

The government has also started using ML in the tax assessment process. Algorithms flag a suspicious filing and follow up with the individual who filed it. The follow-up uses a structured questionnaire that is generated using ML. Based on the individual's responses, the system either closes the case or sends it to an officer for investigation.[340]

Amazon Web Services (AWS) has partnered with Common Service Centers (CSCs) to optimise the delivery of services. CSCs are centres set up across rural and remote parts of India to help deliver the government's e-services.[341] One of the applications offered by AWS is Textract, which uses ML to extract text and structured data from scanned documents. It can process millions of document pages within hours.[342]



Challenges for adoption

Key challenges to the adoption of AI in this sector emanate from the uneven and fragmented data and digitalisation practices across different government departments, which indicate low institutional readiness.[343] Not only does the level of detail in data inputs vary across departments, but data formats and standards used are also uneven. In an interview with The Indian Express, an individual working with Amazon India's public sector team remarked that the lack of open data sets makes it hard to develop AI-enabled applications. Even on India's open government data platform, data.gov, the data sets available are summaries of dashboards. Raw data needed for machine learning is often unavailable.[344] At the citizen end, poor connectivity, relatively low internet and smartphone penetration, and the lack of digital literacy act as barriers to accessing technology-based solutions.[345]

Frameworks and institutions for data governance, such as the Personal Data Protection Bill, are still under development. Data handling practices by government agencies have also demonstrated a poor understanding of privacy and security concerns at various levels of government.[346] Inadequate public procurement mechanisms also impede adoption. Start-ups and smaller companies that develop AI solutions are unable to apply to tenders put out by the government because of factors such as tight application windows, high deposit amounts, and minimum turnover requirements.[347]

For civil society organisations, access to data and uptake by citizens is a challenge.[348] Lack of funds and existing business models also prevent civil society organisations from scaling up solutions. [349]

Potential benefits

The increase in data along with the emergence of numerous public open data movements[350] has led to greater attention to the role of technology in delivering public services and civic participation. In 2012, the Indian government announced its National Data Sharing and Accessibility Policy, along with the Open Government Data Initiative.[351] To leverage open data, several state governments conduct regular hackathon events for civic tech.[352]

In India, the interaction and flow of information between citizens and governments could be enhanced by civic tech as has been done in other countries. For example, chatbots developed by Microsoft for the Government of Singapore are intended to be digital representatives. Similarly, a government office in North Carolina uses conversational-AI to free up operators' lines, rerouting basic calls to the chatbots.[353] A study conducted in Brazil to examine the role AI can play in empowering political participation found that AI-solutions can and should be deployed to enable diffused forms of political participation, which will empower citizens to take ownership of public administration.[354]

Gov-tech applications can also improve efficiency in government processes, service delivery and citizen experience of government services. Estonia, for example, uses AI extensively in the public sector. The government has saved €665,000 on subsidies they provide to farmers who mow their hay fields. Earlier, the follow-up was done in person and less than 10% of the ground was covered. The government is now using ML models that analyse satellite imagery to check if farms have been mowed.[355]

The Estonian government also uses video analytics to approximate the number of cars and bottlenecks on different roads. They combine these data with other datasets on roads to decide where improvements are required and investments need to be made.[356] Working in tandem with the World Bank and Microsoft, Estonia has developed an AI-enabled system that scans healthcare records and ascertains which patients need health check-ups. They have also started using NLP to transcribe court proceedings.[357] Solutions like these could help the understaffed and overburdened Indian government help carry out its functions better.

Potential harm

The key risk of using AI to optimise processes and improve service delivery is the potential for profiling, discrimination and misuse that could arise from the centralisation and combination of different government databases. Data breaches in the past that exposed medical records,[358] Aadhaar data,[359] as well as bank records[360] indicate poor cybersecurity practices and lack of technological capacity at several levels of government.[361]

There are concerns around privacy and security of data in the use of AI not just by the government, but also civil society organisations and startups developing applications for citizen engagement. Records maintained by the Indian - Computer Emergency Response Team (CERT-In) indicate that the number of reported cybersecurity incidents is rising every year.[362] The number of incidents points to inadequate policies, capacities, and safeguards around cybersecurity.

The black box nature of ML algorithms makes it almost impossible to know why and how certain decisions are taken. This is generally a problem with automated decision-making systems, but it becomes more contentious when the use of these systems by the government could potentially exclude individuals from availing themselves of benefits to which they are entitled. For example, the ML-based authentication system for pensioners is reportedly only 93% accurate,[363] meaning that inaccuracies could preclude an individual who is entitled to a pension from claiming it. Explainability of these systems is therefore critical. Measures similar to New York's task force on automated decision-making could be instituted to audit these systems.[364]

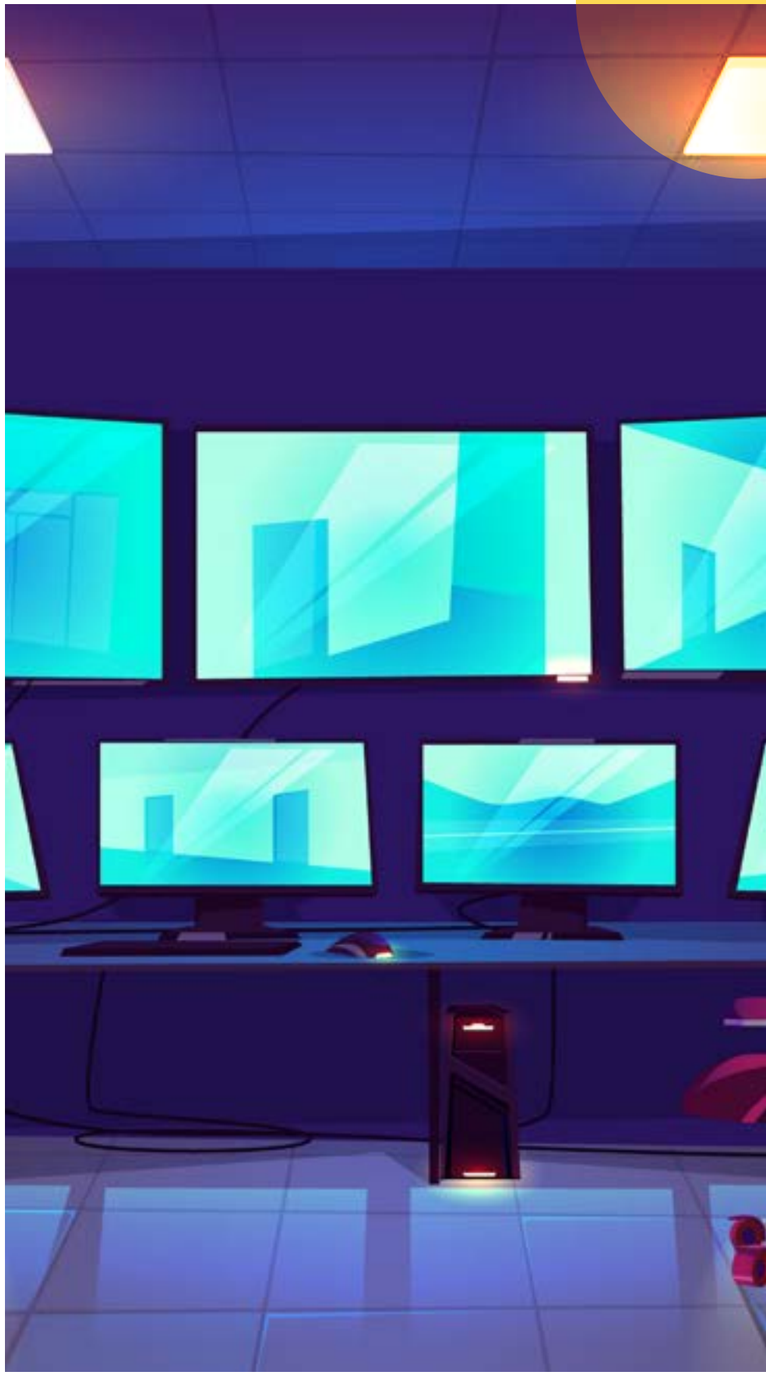
Much of the knowledge in public dealings is a part of situated practices and tacit knowledge built over years of experience. When ML applications are used for decision-making in systems of governance, they are likely to impact the role and agency of locally embedded political representatives, bureaucrats and other officials.

Several applications developed by governments, civil society organisations and startups are available only in a few vernacular languages. Given the existing low levels of digital fluency amongst a wide section of the Indian population, and lack of access to digital devices, there is the risk of social exclusion of vulnerable groups such as women, children, and the elderly.[365]

10. Workplace

Organisations across the world are using AI in the workplace. According to Deloitte's 2019 Global Human Capital Trends report, 41% of respondents of the survey were using automation "extensively" across many areas of their organisations,[366] including AI for hiring practices, managing workflows, and automation of microtasks at work. A Global Talent Trends report by Mercer in 2019, indicated that more than 40% of US employers were already using chatbots to engage candidates during the hiring process, and 38% were using them for employee self-services[367] such as automated timecard verification. Gartner, Inc., a research and advisory company, predicts that by 2021, 70% of organisations will have integrated AI into the workplace to enhance employee productivity.[368]

In India too there is increased automation of tasks and activities through the integration of AI in the workplace. A study of AI at Work on behalf of Oracle and Future Workplace, covering around 8,000 employees, managers and HR leaders across 10 countries, has found that India ranks higher than even some industrialised economies on the use of AI for administrative purposes.[369] Deloitte's 2019 Global Human Capital Trends report suggests that 22% of Indian companies have already begun to leverage AI to provide HR solutions.[370] Additionally, a 2019 report on the State of HR Technologies by People Matters, a HR media organisation in India, stated that about 20% of firms were planning to invest over $140,000 (Rs. 1 Crore) in HR technologies in that financial year.[371]



Main AI-based interventions

We have identified 3 types of AI-based products and services in the sector.

Task optimisation and automation

There are instances of ML and computer vision being used to automate repetitive tasks in the workplace. This is carried out by observing the performance of a task by an employee combined with any additional relevant data. Soroco is working with a number of enterprise clients to track employee activity, and then use the data collected to build automated pipelines. A chatbot is another instance of automation, used primarily for customer service calls. It either automatically answers queries or provides the customer support system with options of answers to queries. Companies like Uniphore are working on building systems that can completely automate the tasks performed by people at call centres.

Employee monitoring and engagement

There are increasing instances of AI being used for employee surveillance and monitoring. For example, AIndra is developing a facial recognition-based attendance system that tracks employee check-in and check-out times.
Betterplace, a lifecycle management platform reliant on deep-learning algorithms, provides for the management of a blue-collar workforce. It enables onboarding of employees, background verification and even attendance tracking, using geo-fencing based facial recognition. It uses data generated on employees, such as willingness to learn or family structure, to determine ratings of employees.[372] Using computer vision-powered CCTV, Persistent Systems monitors the factory floor to ensure that employees are wearing required safety gear, such as helmets, when at work.

Companies are also using chatbots to improve employee engagement, gauge employee moods, and predict attrition. Infeedo has developed a chatbot called Amber that engages with employees at regular intervals to help HR gauge workplace satisfaction through tonality, sentiment and textual analysis. The Mahindra Group has similarly launched an onscreen bot to gauge employee mood. The AI-powered system will engage with employees throughout the day with questions like “How are you feeling?” and “What is making you feel low?” The insights from the bot are then used to nudge managers to attend to employees who are feeling low.[373]

Streamline hiring practices

There are instances of companies using AI/ML systems to optimise their hiring processes and talent acquisition. Using AI allows companies to sift through numerous profiles and resumes, and shortlist candidates based on set preferences. For example, Belong.co uses machine learning and analytics to enable outbound hiring, by identifying talent from across various professional networking platforms. The application generates insights about prospective candidates, and assesses their suitability for the job. It also provides insights into whether the candidate is likely to change jobs. Similarly, KnackApp evaluates talent and identifies traits of job applicants through a gamified platform. The candidate's performance data on the game is run through machine learning and statistical models built using cognitive and neuroscience findings to identify the person's stable traits. There are also instances of ML algorithms being used by companies like CVViZ to screen resumes.

AI can also be used to automatically interact with candidates, and use this engagement to create a pipeline of the most suitable candidates.[374] AutoView, is an instance of a virtual interview platform developed by Aspiring Minds, that helps interviewers automate the interview process. The interviewer can configure the interview questions, flow, and interview format. The platform automatically sets up the interview call, and has a bot that conducts the interview. The system is equipped with video analytics and NLP capabilities to evaluate the interviewee's body language, Emotional Intelligence, domain knowledge and personal characteristics, and provides an analytics report and score to the recruiter to make hiring decisions.

Other companies like Vahan are using chatbots integrated with WhatsApp, and enabled with Hinglish to help blue-collar workers find jobs. The chatbot collects relevant details from the applicant and assesses how serious the applicant is about finding a job. Serious job applicants are then attended to by human recruiters. Teamlease is another recruitment platform that caters to entry-level and blue-collar jobs by matching employees to available jobs. It allows workers to check, search and apply for jobs in their local languages. Using AI/ML, the interview process is based on the answers provided by the candidate to questions framed around the candidate's CV. Using open-ended questions, it matches with previously fed data and close-ended questions are used for elimination. Based on CVs and the job, it assigns a tag with a percentage of suitability of the candidate for the job.

Challenges for adoption

The size of the firm, and the cost of incorporating AI systems, play a major role in adoption. Unlike their larger counterparts, small and medium sized firms continue to wrestle with the adoption, even though they may recognise the benefits. Such firms are likely to weigh more seriously the financial cost of introducing these technologies[375] against the potential efficiency that AI might provide. The benefits of reducing labour and improving productivity might not be incentive enough to cut back on labour costs, especially because it is difficult to financially quantify some of the benefits of AI. This is particularly important in developing countries such as India, as the cost of labour is so low that automation through AI might result in higher costs.[376] Companies also say that the lack of skilled professionals impedes adoption.[377] NASSCOM also predicts that there will be an industry shortage of 230,000 skilled professionals for AI and Big Data by 2021.[378]

A broader concern is, while organisations have recognised the benefits of AI and have been actively adopting it, they do not sufficiently consider the challenges that might arise prior to deployment[379], such as understanding potential use cases or possibly that systems might need to be tailored to certain workplaces. This lack of preparation contributes to the ineffective integration of AI.[380]

Potential benefits

The reason for the uptake of AI at the workplace is largely owing to its ability to enhance efficiency, increase productivity, and optimise workflows. A survey conducted by IFS, a Swedish software company, of around 600 business leaders across industries, revealed that about 60.6% believe that the implementation of AI will help workers be more productive. For example, as repetitive activities are being increasingly automated, administrative tasks such as scheduling/rescheduling or cancelling of meetings that occupy a considerable amount of correspondence and time, could potentially be carried out through AI-powered personal assistants.[381] X.ai, an AI scheduling tool aims to do this by connecting a calendar and a user's preference, and then through a link sent to the recipient, schedules a time slot based on everyone's availability/preferences.[382] Similarly, through AI coaching tools that observe how existing employees perform tasks, new employees could learn to replicate or perform those tasks efficiently.[383]

A global survey on employee attitudes at work, conducted by the Workforce Institute in partnership with Coleman Parkes Research, found that 64% of employees felt that AI helped balance their workload, and 57% believed that AI helped managers make better decisions about choices that would affect individual employees. Goal-setting software that use AI can assist managers and their teams to set and align goals efficiently.[384] AI could also be used to identify employees who might require feedback, and remind managers to provide it in a timely fashion. This could help managers schedule time to offer feedback to their employees.[385]

Additionally, AI could also help to avoid or reduce exposure to dangerous tasks and injuries at the workplace. For example, using a platform that assesses such risks and hazards, a construction company found that there was a 20% reduction in quality and safety problems onsite.[386]

Potential harm

Technologies that track, monitor, and surveil workers without any safeguards in place could undermine privacy. Further, the protections afforded by the Personal Data Protection Bill, 2019, fail to include employees who are not covered by a formal employer-employee relationship. This means that platform workers, self-employed workers, and those who fall within non-standard employment are provided no privacy and data protection rights.[387] These technologies also enable managers to continuously monitor employees, allowing them to exercise a tighter degree of control, and reducing the agency of employees.

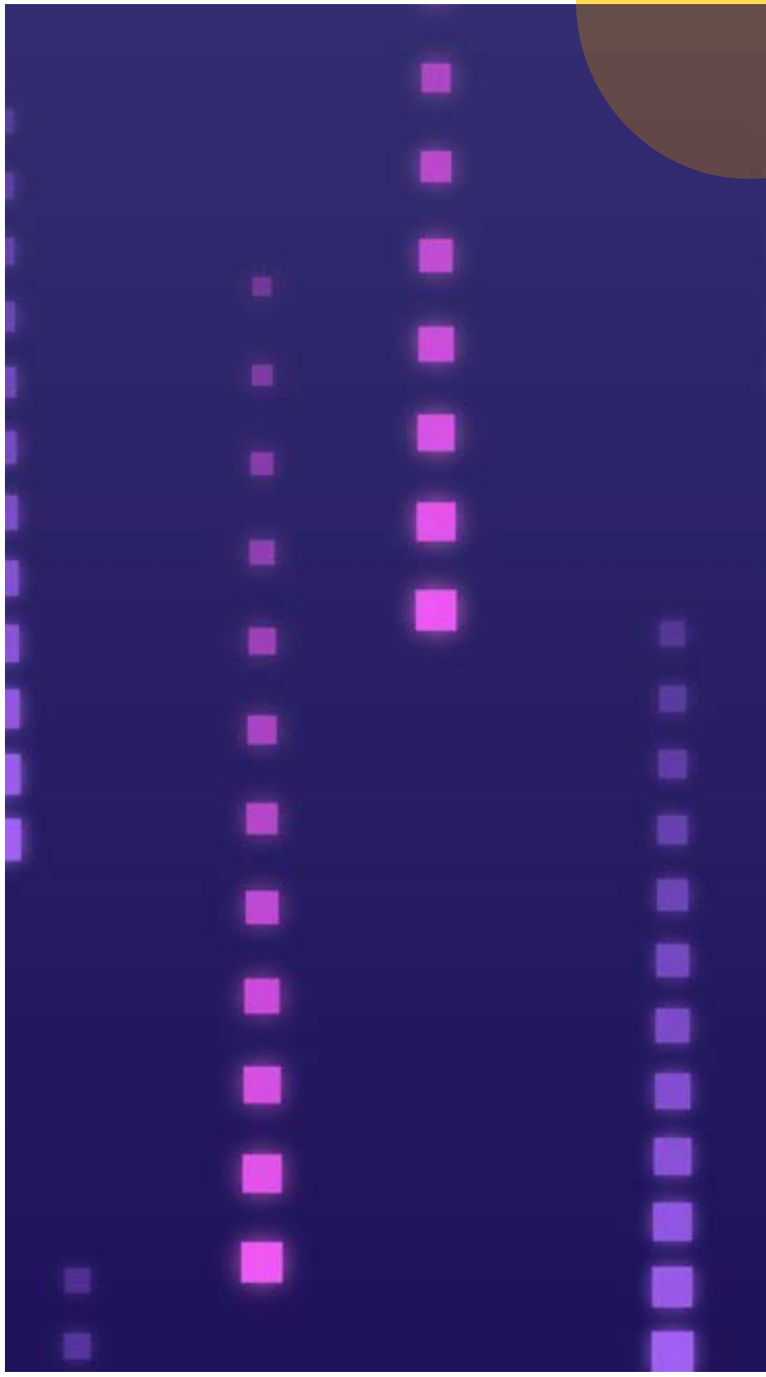
For instance, algorithmic management systems used by on-demand platforms have been found to undermine worker agency and rights.[388] The continuous monitoring of employees, their activities and emotional responses can negatively affect their mental/emotional wellbeing. Technologies that create a 24/7 work environment, could also overwhelm employees and lead to lower levels of engagement.[389] A hiring and screening tool, based on personality diagnostics has been designed to help managers identify individuals who might have pre-disposed features that could cause them to engage in undesirable work behaviour.[390]

The use of algorithmic decision-making systems for talent identification and hiring raises concerns about the entrenchment of biases and discrimination. These technologies bear the risk of reinforcing existing social inequalities based on biased data that may have been used to train these automated hiring models. For example, research from the US shows that African-American names are systematically discriminated against, while perceived white names receive more callbacks for interviews.[391] Similarly, Amazon's hiring algorithm was shown to be systematically biased against hiring women.[392] Discriminatory practices against gender, caste and even religion already exist in Indian workplaces, and impact recruitment processes as well.[393] AI is likely to similarly reproduce these patterns and reinforce such discrimination.

The ability to automate the tasks performed by employees/workers through such extensive monitoring is a cause for additional concern, as the AI applications that are being used to automate and optimise tasks could lead to redundancy of certain jobs and tasks. According to a World Bank Report, 69% of Indian jobs are threatened by automation year-on-year, some of which use AI based applications.[394] As per the World Economic Forum, 54% of Indian workers will be required to undergo reskilling by 2022 to combat the demand for automation.[395]As repetitive and non-cognitive roles/ tasks are being replaced by the growing adoption of AI and increased automation, a large number of low-skill level jobs are being made redundant.[396]. Further, without proper security measures in place, companies can be targets of hacks and data leakages. For instance, certain tasks that might be automated could even involve access to sensitive information, such as payments, without a control mechanism or a check on credentials.[397]

11. Conclusion

Based on the study of the various ways in which AI is being used in India, this concluding chapter identifies some overarching learnings and related recommendations.



WHAT WE LEARNT

Small but incremental benefits are accruing from the deployment of AI and ML-enabled systems.

The deployment of AI and ML-enabled solutions is resulting in small incremental gains across sectors. For example, in the agriculture sector, while not all farmers are able to afford these technologies, a pilot project by Microsoft and ICRISAT demonstrated potential benefits. They developed an application that provides recommendations to farmers which resulted in a 30% increase in yield. In the education sector, a study conducted on Mindspark by J-PAL South Asia compared Mindspark's personalised and adaptive system to traditional methods. The study found that there was a marked improvement in students' language and mathematics learning outcomes. Advances in machine learning techniques have also contributed to progress in other fields such as natural language processing and computer vision. Progress in the field of language translation has also been beneficial in the context of India. Microsoft's Translator, which supports 12 Indian languages, can help native language speakers access information in other languages.

Narratives of the transformative impacts of AI are yet to be matched by current use cases.

Government documents position AI as capable of solving deeply entrenched social sector problems, such as access to quality education and healthcare. Current use cases present a far more fragmented picture, with companies addressing very specific issues in a sector or only optimising backend processes. The bulk of AI adoption in India is directed towards enterprises. The identification of the issue to be addressed through AI is often based on data availability or market opportunity. For example, in the agriculture sector, developers prefer building solutions where data exists and partnering with farmers who have previously adopted some technological solutions. This ends up privileging certain types of customer groups or solutions - such as health wearables for urban consumer markets - and does not address some of the deeper issues in the sectors. Subtle changes may transform certain functions or verticals within a sector, but sectoral transformation will require broader investment in infrastructure, people, and systems.

It is not simply the technology, but its use that also requires closer public scrutiny.

While the black box nature of ML applications raises concerns, it is the domains or ways in which it is used that requires greater public scrutiny. Many applications of ML are fairly innocuous in nature. For example, machine learning is being used for natural language processing and image recognition. In some use cases this enables the digitisation of records and allows building of products and services for different language groups. The use of machine learning systems to aid computer vision for reading and digitising prescriptions and health records, while prone to error, can bring tremendous benefits to health care providers and patients. But computer vision applications are also used to aid automated facial recognition systems, which as argued earlier in this report, can undermine civil liberties and the functioning of healthy democracy. Certain use cases could enable profiling, surveillance and exclusionary outcomes if not built with adequate safeguards.

Many development and deployment challenges are similar across sectors.

Unstructured data, data gaps, limited computational power and storage capacity, and unavailability of talent are common challenges to developing ML-based solutions. Infrastructural constraints, lack of policy and legal guidelines, and market opportunities further constrain the adoption of ML-based applications. For example, even though India doubled the number of individuals in its AI workforce in 2019, a large number of positions remained vacant, even with professionals transitioning to AI from other fields. Similarly, infrastructure gaps remain a huge challenge for adoption across different sectors such as healthcare, policing, agriculture. For example, in agriculture, farm mechanisation is at about only 40% in India. There is also minimal ICT infrastructure in many public hospitals and police departments. Data accessibility is also a shared problem, owing to existing data silos and gaps, unstructured data, and access to accurate and verified data. For example, sectors such as energy and water, and agriculture face difficulties in accessing quality data, owing to poor data collection and fragmented digitisation.

Greater oversight is needed when ML applications are central to decision-making about people, their rights, livelihoods, and relationships.

The reliance on automated decision-making systems for verification and authentication in welfare entitlements, credit eligibility, or insurance premiums requires closer scrutiny. For example, the digital ID authentication system adopted by the Andhra Pradesh Government to verify pensioners, is claimed to be 93% accurate. This still leaves a 7% margin of error, meaning that the system could prevent some individuals from claiming their pension. There is also no indication of any grievance redressal mechanisms to address such errors. Several algorithmic decision-making systems to predict creditworthiness or set insurance premiums are often built on historical data that could reproduce existing societal inequities and lead to discriminatory decisions. Further, the black box nature of many machine learning processes makes explainability a challenge. This, in turn makes it harder, or even impossible, for people to know why certain decisions are being made about them, rendering them unable to contest those decisions.

ML systems that enable the profiling of individuals and groups require adequate checks and balances.

Financial institutions and data analytics companies, amongst others, are using ML applications to develop personalised products and services tailored to consumer experiences across industries, whether for wealth management or optimising energy consumption. However, building granular individual profiles without adequate safeguards in place violates individual privacy and enables harmful practices of profiling and surveillance. For example, in some instances, the use of personality diagnostic tools to aid in hiring practices at the workplace create granular profiles of applicants on the basis of metrics such as self-obsession, temperamental tendencies or impulsiveness. Individuals are also understood in terms of their group characteristics, which can lead to unfair or discriminatory outcomes. For instance, applications that are used to track consumer consumption levels can provide information on location, movements and behavioural patterns. This could identify marginalised groups that are residents of particular areas and lead to exclusionary practices against them. It can also undermine group privacy.

The use of AI in public service systems and safety-critical sectors should be held to higher standards of transparency and accountability.

The use of AI by government agencies for public service delivery has the potential to impact the rights and opportunities of citizens, both in the short term as well as the long term. Many of the systems that are used in the public sector are proprietary and companies are not willing to open their data sets or algorithms to scrutiny. For example, we observed that a large number of AI and ML-based applications that are being used in the policing sector have been developed primarily by private companies. Bias and discrimination are graver concerns because it can mean a denial of constitutionally guaranteed rights and entitlements. The over-reliance on ML-based systems can also reduce the agency and accountability of government officials, as well as discount their tacit knowledge and empathy towards particular contexts. The need for scrutiny extends to safety-critical sectors such as healthcare or policing. The cost of biased or inaccurate systems in these sectors is immense, potentially leading to misdiagnosis, loss of life or wrongful prosecution.

Monopolisation of data and differential access to resources to build ML systems increases market inequities.

Large companies have an advantage in developing ML applications, because of the large amount of data they have at their disposal combined with computing power, data storage capacities and talent. Therefore, developers of enterprise solutions prefer working with large companies since they have more data, which allows ML and AI models to perform better. This makes it harder for smaller companies to compete, since larger companies can leverage AI and ML-based applications to further increase their already massive competitive advantages. Smaller businesses find it hard to compete and many end up selling their businesses to Big Tech companies. The practice is so common now that scaling up to be bought out by Big Tech companies has become a business model.

Uneven distribution of technology gains can entrench existing societal inequities and create new ones.

Current government narratives envision the benefits of AI eventually percolating through society as a whole, via the growth of national wealth and empowerment of people. However, certain consumer groups, social groups, organisations, and institutions are better positioned to leverage ML-based solutions, due to factors such as education, skill levels and access to infrastructure. This differential access to AI-based gains can reproduce existing societal inequities. For example, in agriculture, AI adoption is concentrated primarily in large farming corporations, and has not reached those who might benefit most from it. Similarly, ML systems enable productivity gains for companies, but these benefits are not distributed to labour and many risk losing their jobs. A report by the job and recruitment portal, Shine, found that up to one-third of existing jobs across sectors in India are likely to be automated by 2022. Labour share of national income is already in decline,[398] and ML-based systems could further exacerbate such inequities.[399]

WHAT WE RECOMMEND

Policy interventions should be based on an evaluation of the social impact of ML applications.

The threshold for public scrutiny should not be the specific computational technique i.e., machine learning or deep learning, but the societal impact of algorithmic systems.

Four key issues should be considered. First, the impact of algorithmic systems on people, their agency and rights. Second, the impact on healthy and competitive markets. Third, the impact that algorithmic systems have on democracy, state-society relations, and accountability. And finally, the likely environmental impacts of developing and deploying AI systems. Assessing the impact of algorithmic systems along the lines of these four verticals, will also direct attention to the appropriateness of algorithmic systems, rather than the technique in use.

Investments in state and regulatory capacity, along with analog components of digital society are needed.

Governments need to build their own technical knowledge and capacity so that they can evaluate technology vendors and design appropriate procurement guidelines and policy frameworks. Regulatory capacity also needs to be strengthened to be able to identify and prevent harm. In India, there are several instances of government officials and institutions mishandling sensitive data and examples of poor cybersecurity practices, which result in loss of privacy of individuals and exposure to cybersecurity threats.

Investments will also have to be made in better digital literacy and data practices of government officials. Finally, without investments into the analogue components of the digital economy, such as education and infrastructure, the distribution of AI gains will be inequitable. Policies will also be needed for the better distribution of technology gains, such as social welfare policies that protect workers from the impacts of automation.

Red lines should be drawn around certain types of use.

Applications of AI that are a direct threat to human rights, constitutional liberties, and democracy should be strictly regulated.

Automated facial recognition and predictive policing, for example, not only undermine individual rights but can also have a chilling effect on democracy. The risk of false identification and discrimination is also high in these systems.

In such use cases, strict rules and conditions must be established and enforced. In 2020 Portland, and other cities in the US have completely banned the government use of facial recognition systems.[400] Portland city has even banned the corporate use of facial recognition in public spaces.[401] Similarly, several countries have called for the ban on autonomous weapons for warfare.[402]

Data protection frameworks need to be accompanied by community rights and accountability frameworks.

Current data protection frameworks are inadequate for addressing AI harm. There is now ample evidence to show the limitations of a consent-based model to data privacy.[403] Further, new ML techniques make the re-identification of individuals possible, despite anonymisation efforts.[404] Stipulations for data minimisation and purpose limitation can provide partial protection, but only when accompanied by penalties for misuse. For instance, the Swedish data protection authority banned the use of facial recognition systems in schools on the basis of the data minimisation principle.[405]

However, the individualistic approach of data privacy and protection policies is unable to capture the full range of harm posed by AI systems, such as discrimination and exclusion.[406] We need to establish stronger community rights and accountability measures to determine where AI should be used and to hold data collectors and processors accountable for unsanctioned or harmful use. Collective rights may coalesce on issues like restrictions on mass surveillance and profiling for discriminatory purposes that are fundamental to the health of societies and markets.[407] Greater transparency and accountability is particularly important in the public sector. For example, both Helsinki and Amsterdam have created public AI registries of how each city government uses algorithms to deliver services, which datasets were used to train a model, a description of how an algorithm is used, how humans utilise the prediction, and how algorithms were assessed for potential bias or risks.[408]

Risk management approaches must be accompanied by upstream management of technological innovation processes.

Three broad approaches to addressing AI harm are clearly emerging - ethical[409], computational[410], and human rights frameworks.[411] All provide crucial insights but are likely to prove inadequate. Ethical frameworks are non-binding and not enforceable. Technological approaches do not account for differences in social context - fairness, for example, is a property of social systems, not technical systems.[412] However, technological fixes alone will not be enough. Fairness, for example, is the property of social systems, not technical systems, and is likely to differ widely across social contexts.[413] A third and more promising direction is the turn toward the application of international human rights frameworks, which are universal and binding, and codified in a body of International law.

However, as noted earlier, in an AI world, harm is not just individual, but societal. They are also not necessarily discrete acts or outcomes - a single instance of harm can be unrecognizable, but many taken together can significantly alter societal values and understandings. Rights require corresponding duty bearers, typically the state or other delegated organisations.

Recent evidence shows, however, that states, including liberal democracies, are acquiring AI-based surveillance technologies at a faster rate than ever before.[414] Rights-based approaches also assume that systems of redressal are functioning and accessible to all, whereas, in fact, they are least accessible and functioning for those who are most marginalised and also most impacted.

These approaches, while important, have to be accompanied by greater attention to innovation processes, addressing technology governance upstream.

This then turns attention to how AI, as a field, is developing - the incentives, actors, and institutions steering AI trajectories. The innovation process must be more open and inclusive, to steer innovation trajectories to align with societal wellbeing. This also necessitates market policies to enable a healthy and competitive innovation ecosystem; better linkages between technologists and social science researchers; as well as sector specific guidelines.

Annex I: Use Case Tables

Agriculture

Use Case	Description	Vendor/ Developer
Precision farming and agribots	ML models which provide farmers with real-time advisories on efficient use of inputs such as seeds, water, and pesticides. Technologies such as computer vision and IoT sensors are used to collect data. This data is processed by ML models which also factor in information such as weather data to generate advisories Agricultural robots or agribots are robots that carry out tasks such as planting seeds, weeding, and harvesting	Fasal TartanSense
Farm-to-Market supply chains	ML models that optimise the supply chain and connect farmers to businesses. Some solutions also incorporate the use of technologies such as computer vision and robots to inspect the quality of produce and provide automated grading and sorting solutions at various points in the supply chain	Krishihub Gobasco Sensovision Systems Occipital Tech
Financial solutions for farmers	ML models that use computer vision to analyse images and estimate crop yield for credit and risk assessments	Cropin ICICI Bank IBM

BFSI

Use Case	Description	Vendor/ Developer
AI-assisted onboarding solutions	Platforms which collect customer information and run background checks on customers to ensure smooth and quick customer onboarding	Signzy
Alternate credit scoring for retail lending	AI algorithms used to process data of a loan applicant, using various signals to underwrite them in order to provide loans without security	OptaCredit i3systems CreditVidya Monsoon CreditTech
Claims assessment for insurance	AI-based systems which enable identification of standard data from each claim document and decision-making on the claims	i3systems
Transactional bots and personalised financial services	Digital assistants that help users navigate their finance plans, savings and spending to increase user engagement and improve the overall user experience of the financial product	Arthayantra UTI Mutual Funds
Client risk profile	AI-based system to automate the categorisation of clients depending on their risk profile, from low to high. Building on the categorisation work, advisors can decide to associate financial products for each risk profile and offer them to clients in an automated way	Artivatic.ai Tata Quant Fund
Algorithmic trading	AI algorithm to detect patterns usually difficult to spot by a human, and to react faster than human traders. It can execute trades automatically based on the insight derived from the data	Arque Tech Auquan

Collectability scoring and profiling to drive overall collection strategy	AI algorithms which are used to create a loan payback score by profiling loanees based on transaction data from smartphones, to design nudges for reminding customers to pay their loans or help businesses devise recovery strategies.	CreditMate
AI mechanism for rumour detection	Verification mechanism to detect and mitigate potential risks of market manipulation, rumour, and reduce information asymmetry arising on digital media platforms, including social media. It provides accurate information involving listed companies and BSE through the Exchange website, for the benefit of investors	BSE
Real-time fraud detection	ML-driven fraud detection using historic financial data sets provided by the client as training data	EdgeVerve (Infosys subsidiary)
Valuation models	AI models to quickly calculate the valuation of an asset using data points around the asset. These data points are what a human would use to value the asset (e.g., the creator of a painting), but the model learns which weights to assign to each data point by using historical data	Deloitte
Insurance claims processing	AI-powered system aided by computer vision to process insurance claims. The computer vision systems assess the damages and help process claims that are valid	ICICI Lombard
Voice authentication/verification	Speech recognition-based systems that use the user's voice to authenticate access to their account	Citibank
Customer nudging for increased usage and relevant feature discovery via personalised banking user flows	AI-powered system that profiles customers at scale and then nudges them towards regular product usage via personalised banking journeys	3LOQ

Image and voice-based user flows for low-literate banking clients	Enabling user journeys with images and text to voice transcription, to allow low-literate users to better navigate banking services on digital platforms. The applications are also enabled with speech recognition for the users to navigate using their voice	Navana Tech (formerly LitOS)
Conversational banking and virtual assistant	AI-based virtual assistant/chatbot trained to respond to queries, provide personalised options, and assist in basic financial transactions	ICICI Bank
Wealth management	ML to generate customer insights in order to personalise service offering to clients and for wealth management	IndMoney
ATM cash-level detection	ML model for cash-level optimisation at ATMs	Citibank
Gesture banking	Hand gesture recognition for the purpose of carrying out banking services	HDFC Bank

Education

Use Case	Description	Vendor/ Developer
Personalised and adaptive learning	Personalised and adaptive learning encompasses the use of ML algorithms to assess a student's proficiency and tailor learning material according to each individual's needs and deficiencies	Jungroo Learning, Mindspark, Embibe
Remote proctoring and automated assessments	Facial recognition technology is used to authenticate, authorise and control remote examinations	UpGrad, Mercer Mettl ProctorU, Wheebox

Prediction of school drop-outs	ML algorithms are used to predict which students are at a high risk of dropping out of school, based on a number of different indicators	Microsoft Azure
NLP for language acquisition and communication	ML systems for NLP tasks such as converting speech to text or text to speech and language translations are being used to impart language education and improve communication skills of students	Learning Matters,
Career guidance	ML applications are being used to match students with prospective colleges and programmes and provide insights into where a student has a high probability of acceptance	Leverage Edu, WUDI, Mindler
Education loan underwriting	Alternate credit scoring methods using ML are used to predict future earning potential of students to underwrite loans.	Credenc Credelia, Shiksha Finance Eduvanz
Facial recognition for attendance	Automated facial recognition systems are used to authenticate identity and mark attendance	Tamil Nadu e-Governance Agency (TNeGA)

Energy and Water

Use Case	Description	Vendor/ Developer
Energy-use forecasting and response	AI algorithms used to forecast energy usage across the grid, to optimise energy distribution and save energy	Avrio Energy Quenext
Detection of theft of electricity and meter tampering	AI algorithms to detect abnormal usage on the grid and alert utilities companies	Tata Power Delhi Distribution (TPDDL) and SAP Technologies Avrio Energy
Wind power-yield optimisation	AI-based systems to enable power providers to optimise generation efficiency with real-time adjustments across their assets	Mahindra TEQO
Maximising solar energy generation	AI-based software to help solar firms understand how much solar power can be installed and create engineering design that maximises solar energy generation. AI is used to cut engineering time and design rooftop solar systems for better energy output	Solar Labs SenseHawk
Grid hazard risk mapping	AI-based systems to monitor assets distributed across wide areas for potential weather hazard and imbalances in the network	Quenext
Energy consumption insights	Advanced visualisation engine to provide end users with real-time energy monitoring data and control machine/equipment that drives savings	Energyly
Mapping energy footprints	AI systems to find the “fingerprint” of each appliance using data from the consumer’s electricity meter	Sustlabs

Enable fair and efficient water distribution	IoT, machine learning, predictive analytics and big data technologies used to make water distribution fair and efficient in major Indian cities	EqWater
Water level monitoring	A smart water management system, that uses AI to measure water levels and analyse usage	Agua
Water quality testing	AI system which uses water quality variables like pH, TS, COD to predict dissolved oxygen (DO) and biological oxygen demand (BOD) to assess the quality of water of the Gomti river	Researchers at IIT Kanpur and Indian Institute of Toxicology Research

Enterprise Solutions

Use Case	Description	Vendor/ Developer
Data driven insights for improved decision making	AI-enabled systems that derive business intelligence using different sources of data	Synctactic AI Smarten Wesense.ai Myntra Sparrosense
Improved customer engagement and customer service	Chatbots use NLP and ML to answer commonly asked queries and provide information. Some tools analyse conversations to provide company representatives with real-time assistance and generate insights	Haptik Uniphore PNB MetLife

Process and task optimisation and automation	ML and robotic process automation (RPA)-based systems that automate task pipelines	Soroco JIFFY.ai Spotdraft TrustChekr Zwayam
Personalisation	ML-based applications that mine user data for insights on user behaviour and preferences and also personalise offerings. Some systems use image recognition to gauge engagement	InMobi AbsolutData Aegon Life Insurance Sensovision

Healthcare

Use Case	Description	Vendor/ Developer
Disease detection	ML applications are being used in several instances to aid doctors in the early detection of diseases and pathologies. AI chatbot chats with users and checks their symptoms. The system then provides them with health advice and guidance	Niramai Qure.ai Google Microsoft Wysa (Touchkin) Woebot
Disease forecasting	ML algorithms are used to predict the spread of diseases at a population level as well as to calculate the probability that an individual may contract a condition	Wadhwani AI

Personalised healthcare	ML algorithms are being used to deliver personalised treatment plans for patients	MitraBiotech Healthi
Remote health monitoring	ML algorithms are being applied to remote health monitoring systems for real-time data analysis and to generate predictive trends regarding a patient's vitals	StasisLabs Citta AI
Back-end process optimisation	AI is being used across operational pipelines in healthcare institutions. ML algorithms are used to predict hospital stay durations and patient churn-rates to optimise the usage of beds in the hospital ML is being used in health insurance services for claim processing and detecting claims fraud	Wadhwani AI ICICI Lombard Acko Insurance
Medical R&D and training	Deep learning techniques are used for drug discovery and advanced genomics ML-based simulators are being used for medical training	Elucidata Vingyani MedAchievers
Assistive surgery	AI-assisted robotics are used to guide the surgeon's instrument during a procedure	Apex Heart Institute, Ahmedabad

Policing

Use Case	Description	Vendor/ Developer
Real-time monitoring and crime detection	Computer vision is used to automatically identify people, and detect violations of the law in public places and institutions	FaceTagr Staqu
Preemptive policing	ML-based data analytics to generate statistical insights on crime patterns and criminal activity hotspots for the purpose of predictive policing	(AASMA) developed by IIIT-D CMAPS (ISRO)
Internal efficiency management and checks	Police records are being digitised with the help of OCR	Staqu
Public-facing police interventions	Robots deployed to perform duties of the front office of the police headquarters. They receive visitors and direct them to different places in the police station as and when required	H-BoTs

Public Tech

Use Case	Description	Vendor/ Developer
Citizen engagement	ML and NLP-powered chatbots that answer queries and provide information. Some solutions use NLP to make information accessible	CoRover Floatbot Civis Nyaaya
Optimisation of processes and services	ML models that automate tasks	Vision-Box Amazon Web Services

Workplace

Use Case	Description	Vendor/ Developer
Employee engagement and attrition analysis	Chatbots used for employee engagement and to understand each employees state of mind by analysing conversations	Amber (Infeedo) Bash.ai
Voice AI for call centres	AI-based platform to provide call centre agents with real-time feedback on customer sentiment and guide them towards the next best action during a customer call. The platform listens to the call stream in real time, uses deep learning and natural language processing (NLP) to understand the context to generate suggestions for the agent	Observe.ai Uniphore Software

Talent discovery and assessment through smart games	Mobile games to gauge personality traits and skills to evaluate suitability for various job profiles	KnackApp PerspectAI
Resume screening and candidate recommendation	Machine learning algorithms are used to parse resumes to extract and analyse information, and map talent to the relevant profiles	Skillate
Worker safety monitoring	AI-based video surveillance for monitoring workers in dangerous environments and ensuring safety compliance	Uncanny Vision Persistent Systems
Task-automation pipelines using current workflows of individual workers	AI-based systems to observe employees carrying out their tasks by tracking all actions on their systems and using this data to build automation pipelines for the task	Sorocco
AI-based attendance systems	Facial recognition-based attendance system that tracks employees' check-in and check-out times from the office	Aindra
AI-based hiring and talent management	Using machine learning and analytics to enable outbound hiring, by identifying talent from across various professional networking platforms and creating insights about such individuals. This helps companies identify the talent that needs to be engaged and if the candidate aligns with the job requirements. It also provides insights into the probability of the candidate moving	Belong.co
Job discovery for blue collar jobs	AI chatbot integrated with WhatsApp and enabled with Hinglish to help blue-collared labour find jobs. The chatbot collects information about candidates through conversation on the platform and assesses the applicant's seriousness for the job. Serious applicants are then attended to by human recruiters to help them find jobs	Vahan

Automated screening for hiring	ML algorithms are used to screen and understand resumes contextually. The screened resumes are then matched with the respective job profiles and provided a relative ranking with respect to all the resumes that are matched with the job profile	CVViZ
Virtual interview bot	Video analytics and NLP-based systems are used to automate interview processes. The interviewer can configure the interview questions, flow and interview format. The platform automatically sets up the interview call and has a bot that conducts the interview	AutoView (Aspiring Minds)
Blue-collar workforce lifecycle management platform	Through deep learning, it provides for the management of the blue-collar workforce. It assists in hiring and onboarding employees, conducts back-verification and manages employees through attendance tracking, provides for automated salary disbursals, and also provides for chatbot based training	Betterplace.co.in
Recruitment platform for entry-level and blue-collar jobs	Employing AI/ML, it tailors interview processes and questions posed, based on the responses of the candidate. It then assigns tags based on the candidate's CV, the job available and determines if the candidate is a match	TeamLease

Annex II: Note on Method

This research was conducted over a period of 7 months, between June 2019 and December 2019. This research utilised a combination of random and non-random purposive sampling followed by structured and semi-structured interviews with 35+ stakeholders and experts across different sectors. Random Sampling was conducted using the Crunchbase database. In a random sample, every unit of a total population of objects has an equal chance of being chosen. Companies were screened using keywords such as 'Artificial Intelligence', 'Machine Learning', 'Computer Vision', 'Image Processing', 'Natural Language Processing', and 'Intelligent Systems' to identify and select companies that claim to be working on ML. Additional database searches were also conducted on Naukri.com and AngelList to identify companies posting jobs related to Artificial intelligence and online grey literature that listed various startups working on AI.

Based on the selected sample, 16 dominant sectors were identified where AI adoption was high or where there was a call for AI adoption in the public discourse. Finally, 9 key sectors were identified for the research. Sector selection was based on two factors: first, the highest potential or likelihood of social implications, hence the need for public scrutiny and second, those sectors which had a large presence in civic or developmental work. Telecommunications, legal and disaster management were not selected for further research because AI-adoption was not very prevalent in any, while defence and army were not selected due to the lack of access.

Non-random sampling, was used to purposely identify experts working on AI research to understand and identify use cases, AI discourses and AI adoption across sectors. Along with experts, 4-5 stakeholders were identified across each of the 9 sectors, generating a stratified sample of sector stakeholders to ensure that the sampling is representative and covers the breadth of the ecosystem adequately. Interviews were conducted over the phone, via video call and in person and typically lasted between 45 minutes to one hour. Each interview was conducted after obtaining the informed consent from respondents.

GLOSSARY

Algorithm: An algorithm is a finite sequence of well-defined, computer-implementable instructions, typically to solve a class of problems or to perform a computation.

Artificial Intelligence of Things (AIoT): The application of Artificial Intelligence to IoT devices so it can collect, process and analyse data to make decisions.

Artificial Neural Networks: Computational model that simulates biological neural networks. It consists of several processing elements that receive inputs and deliver outputs based on their predefined activation functions.

Automated decision systems: Systems that use algorithms to assist or replace human decision making.

Automated trading: Uses predefined algorithms based on variables such as time, price, quantity or other mathematical models, to execute trading orders.

Bias: There are both societal and statistical definitions of bias that come into play in AI. The societal definition of bias is an inclination or prejudice for or against a person or group, especially in a way that is considered to be unfair. The statistical definition of bias is the difference between the estimated—or predicted—value and the true value. In other words, the difference between what a system predicts and what actually happens.

Big Data: Datasets that are too large or complex for traditional data-processing software to analyse. The increasing availability of big data, thanks to society's ever-expanding internet use, coupled with rapid improvements in computing power, has enabled the significant advances in AI in the past 10 years.

Black Box AI: Black box AI is any artificial intelligence system whose inputs and operations are not visible to the user or another interested party. A black box, in a general sense, is an impenetrable system.

Chatbot: An artificial conversational entity that is AI-based to simulate interactive human converversation.

Computer Vision: Computer vision is an interdisciplinary scientific field that deals with how computers can gain high-level understanding from digital images or videos. From the perspective of engineering, it seeks to understand and automate tasks that can be done by the human visual system.

Data Mining: The process of discovering patterns and extracting information from large datasets. In the era of big data, data mining is often facilitated by machine learning.

Deep Learning: A machine learning technique which uses structures called "neural networks" that are inspired by the human brain. These consist of a set of layered units, modelled after neurons. Each layer of units processes a set of input values and produces output values that are passed onto the next layer of units.

Explainable AI: AI whose decision-making process can be explained.

General AI: This refers to the goal of computers exhibiting intelligence across multiple domains to be, at the very least, at par with human intelligence.

Gesture banking: Banking services that use motion-sensors to recognise hand and body gestures for the purposes of carrying out transactions/services.

Internet of Things (IoT): The Internet of things (IoT) is a system of interrelated computing devices, mechanical and digital machines provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Machine Learning: A branch of AI in which a computer learns from experience (data) through the use of algorithms and statistical models, to improve its accuracy in predicting outcomes, without being explicitly programmed to do so. The resulting output from this process is called a model.

Narrow AI: A single-task application of artificial intelligence for uses such as image recognition, language translation, and autonomous vehicles.

Natural language processing (NLP): It is a branch of artificial intelligence that helps computers understand, interpret and manipulate human language. NLP draws from many disciplines, including computer science and computational linguistics, in its pursuit to fill the gap between human communication and computer understanding.

GLOSSARY

Optical Character Recognition (OCR): It is a technology that recognises text within a digital image. It is commonly used to recognise text in scanned documents, but it serves many other purposes as well.

Platform as a Service (PaaS): Cloud platform service that provides a platform and components to create software/applications.

Precision agriculture: An approach to farm management that uses the application of modern information technologies to collect, process and analyse data for decision making.

Predictive analytics: Analyses current and historical data through statistical techniques such as machine learning, data mining and predictive modelling to provide predictions.

Predictive policing: The use of mathematical, predictive or other analytical techniques to forecast crime.

Reinforcement learning: Reinforcement learning trains an algorithm using a reward mechanism, providing feedback when an artificial intelligence agent performs the best action in a particular situation. It's an iterative process: the more rounds of feedback, the better the agent's strategy becomes.

Robotics: The branch of technology that deals with the design, construction, operation, and application of robots.

Robo-advisor: Digital platforms that provide automated and algorithmic-based financial planning.

Robotic Process Automation (RPA): The use of software to automate rule-based and repetitive tasks.

Sentiment analysis: Using NLP, computational linguistics and text analysis to extract and analyse data to understand emotion within subjective information.

Software as a Service (SaaS): Cloud application services that makes software available over the internet via a third party for a subscription fee.

Speech Recognition: A specific ML/DL approach which allows computers to translate spoken language into text. It allows you to use talk-to-text on your smartphone. It is often paired together with natural language processing and is used to power virtual assistants like Siri and Alexa.

Supervised Learning: In supervised learning, the machine has access to labelled data sets, for example apple and orange (labelled by weight and colour), which is then used to train the model to recognise an apple or an orange. The machine is trained, using data which is well labeled. That means some data are already tagged with the correct answer. After that, the machine is provided with a new set of examples (data) so that supervised learning algorithm analyses the training data (set of training examples) and produces a correct outcome from labeled data.

Thermal imaging: The method of using infrared radiation and thermal energy to create images.

Unsupervised machine learning: Programme is trained on an unlabelled and unclassified data set, with the algorithm trying to make sense by extracting underlying or latent features and patterns on its own. Data scientists commonly use unsupervised techniques for discovering hidden patterns and groupings/clusters in new data sets. In unsupervised learning, a learning model is handed a dataset without explicit instructions on what to do with it.

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ENDNOTES

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