TeamLease Digital

iCET - Forces Shaping Future of Technology

ARTIFICIAL INTELLIGENCE

March 2023

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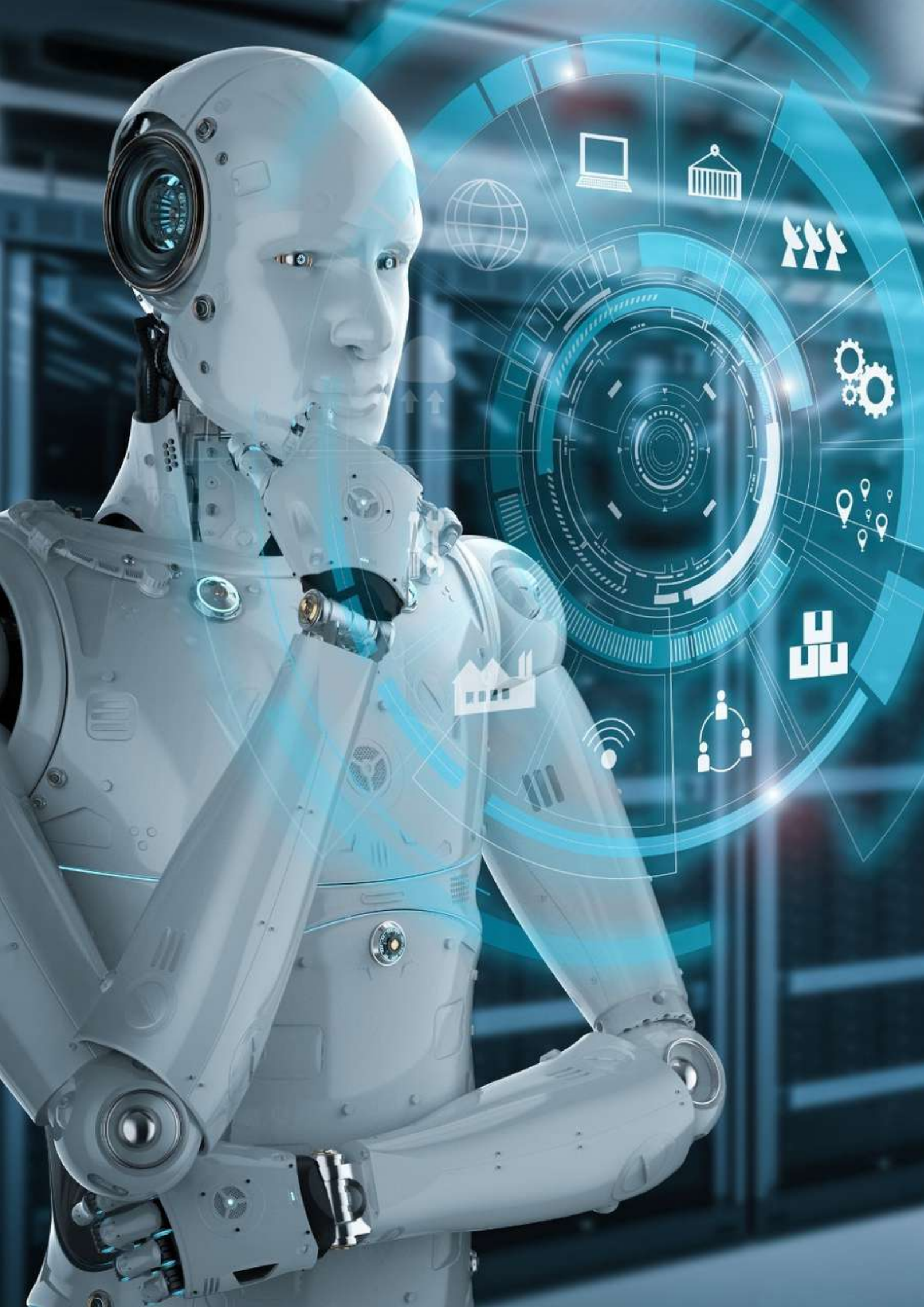
Executive Summary

The world has entered an era of accelerated technology innovation, heavily driven by research and exponential investments are boosting the overall growth of advanced and emerging technologies. Critical and emerging technologies are transforming every industry and enabling an environment to promote adoption and spur innovation. The core potential of these technologies is tremendously expanding and creating new opportunities for every business to innovate, provide better products and services and bring better customer experiences and reduce costs and improve productivity. The latest agreement between India and the US in the form of the Initiative for Critical and Emerging Technologies (iCET) envisages an innovation bridge between both countries by collaborating with India's Tech innovation hubs to promote critical joint research projects in the areas of Artificial Intelligence (AI) and provides momentum to technology cooperation with a focus on joint development and joint production. AI, one of the technologies of iCET, is set to be one among the key areas in the transformation of the economy, society, and the future of the workforce.

The report by TeamLease Digital has shed light on the recently concluded iCET between US and India by exploring growth opportunities specifically in the area of AI technology. The report has attempted to offer a series of simple, bite-sized information to understand what AI is, how it works, and how it is changing the world around us in general and the AI landscape across major industries in terms of key job roles and applications. In this report, we start by providing some key facts on the demand for AI skills in India across occupations and industries. Most interestingly, we examined and estimated the open job roles available for AI career aspirants by using detailed data on job roles and skill requirements for freshers and professionals. In addition to this, we have also attempted to analyze the salary packages available to job seekers who are aspiring to land an AI career. By listing B2B and B2C wide opportunities in AI, the report shows that the demand for AI skills has been growing fast across a wide range of sectors and job roles which is not only limited to IT, its related industries and jobs but also across other industries.

"As countless businesses continue to integrate Critical and Emerging Technologies (CET), businesses are rethinking and reshaping the future of talent. Job seekers who are aspiring to have careers in CET should possess relevant and in-demand skills by repair, prepare and upskill to make their careers future proof."

Sunil C.
Chief Executive Officer, TeamLease Digital



iCET Overview

The meeting of the Indo-US initiative on Critical and Emerging Technologies (iCET) was one of the first-ever bilateral discussions dedicated to technology cooperation. Power politics among nations to gain dominance in critical and advanced technologies, global geopolitics and geo-economic competition, resulted in the announcement of iCET and began the new chapter in Indo-US ties. The iCET initiative was launched with the goal to elevate Indo-US strategic technology partnership and industrial cooperation between the governments, businesses and academic institutions of both the countries. The initiative mainly emphasizes on six key areas identified - strengthening innovation ecosystems, defense innovation and technology cooperation, resilient semiconductor supply chain, space, STEM talent and next generation telecom. iCET promises to position a bilateral partnership between India and US to strengthen the innovation ecosystem and ensure robust cooperation in AI technologies. The development of iCET in coming days is expected to play a significant role to elevate focus areas but also promote business and talent mobility from both sides.

Supplementarily, the recent announcements of the Union Budget like creation of Centres of Excellence for AI boost interdisciplinary research, developing cutting edge applications and scalable problem solutions in the areas of health, agriculture and sustainable cities, outline a big focus on AI and embark on the vision of 'Make AI in India' and 'Make AI work for India'. In a way, the rising scope brings laser sharp focus to AI led skill development by announcing the centers. Additionally, creation of a skilled AI talent pool, Pradhan Mantri Kaushal Vikas Yojana is set to provide on-job training and courses in emerging technologies such as AI. India is also leveraging its G20 presidency and chairmanship of the Global Partnership on AI (GPAI) to bat for innovation in AI and to devise a common framework to govern the emerging technology.

India has all relevant resources to transform into a global technology hub mainly, technological advancements and availability of talented and skilled workforce. These prominent developments in the AI sector are expected to help in scaling the overall AI ecosystem and spawn a number of stakeholders in the domain on the back of a large AI talent pool. Moreover, a greater collaboration with the US on development of iCET in coming days will play a very significant role in elevating Indo-US strategic partnership and establish innovation in key sectors listed in iCET. Also the partnership opportunities of iCET will help India to access digital infrastructure and ensure new opportunities for business.

Critical and Emerging Technologies (CET)

- Advanced Computing
- Advanced Engineering Materials
- Advanced Gas Turbine Engine Technologies
- Advanced Manufacturing
- Advanced and Networked Sensing and Signature Management
- Advanced Nuclear Energy Technologies
- Artificial Intelligence
- Autonomous Systems and Robotics
- Biotechnologies
- Communication and Networking Technologies
- Directed Energy
- Financial Technologies
- Human-Machine Interfaces
- Hypersonics
- Networked Sensors and Sensing
- Quantum Information Technologies
- Renewable Energy Generation and Storage
- Semiconductors and Microelectronics
- Space Technologies and Systems

Note: For definitions of above technologies, please refer to the appendix at the end of the report.

Key iCET - Artificial Intelligence

iCETs are a subset of advanced technologies that are potentially significant to business areas. In fact iCETs are composed of core technologies, one among which is AI, one of the critical and emerging technologies. AI is a branch of computer science, specifically concerned with building and managing smart machines capable of performing tasks that typically require human intelligence. Advancements in iCETs, especially remarkable surges in AI capabilities have led to a wide range of innovations, benefitting the society and economy by its revolution.

Global AI Market

Global AI market size is estimated at $136 bn in 2022 and is expected to grow at CAGR of 37% from 2023-2030

- **$15.7 tn** revenue potential to contribute to global economy by 2030
- Research shows that **45%** of total economic gains by 2030 are from product enhancements, in turn stimulate consumer demand

Indian AI Market

- AI-generated revenue in India stands at **$12.3 bn in 2022**
- AI software segment is expected to grow at a **CAGR of 18%** by the end of 2025

AI Market is expected to grow at a CAGR of 20% to $7.8 bn by 2025

AI Investment

India's investments in AI is growing at CAGR of 30.8% and will reach $881 mn in 2023

- Total global AI investment surged to a record high of **$77.5 bn** in 2021 up from **$36 bn** in 2020
- India's share in global AI investment stands at **1.5%** in 2022

Potential Contribution to Economy

- AI is expected to add **$967 bn** to the Indian economy by 2035 and **$450-500 bn** to the country's GDP by 2025, accounting for **10%** of the country's **$5 tn** GDP target

Expected to contribute up to $15.7 tn to the global economy in 2030

AI Talent Pool

Around 400K AI talent base in India

- India is 3rd largest contributor representing **16%** of global AI talent pool
- **12.8%** of mid to large size organizations in the country have employed a tenth of their workforce with AI professionals

Top Emerging Cities with AI Talent Pool

- Bengaluru has been ranked at 5th position globally according to a study based on talent pool, diversity of talent, investment, and the country's evolution of digital foundations. Other top cities were San Francisco, Boston, New York, and Seattle.
- New Delhi was ranked at 18th, Hyderabad at 19th and Mumbai at 27th.

Bengaluru boasts of the world's 2nd largest AI talent pool

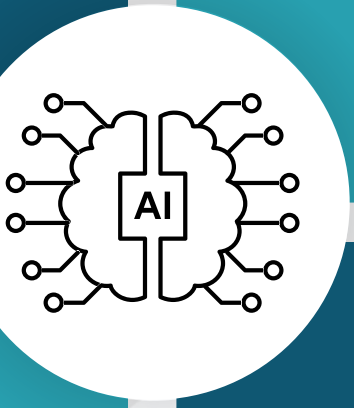
Types of AI

Vision AI

- Generates information from documents, images, or videos
- Uses sensors, cameras, neural networks and ML algorithms
- Applications are facial recognition, object recognition, etc.

Conversational AI

- Capable of voice-based and text-based conversations
- Generates information in an instant
- Applications are chatbots, virtual assistants, etc.



Sense AI

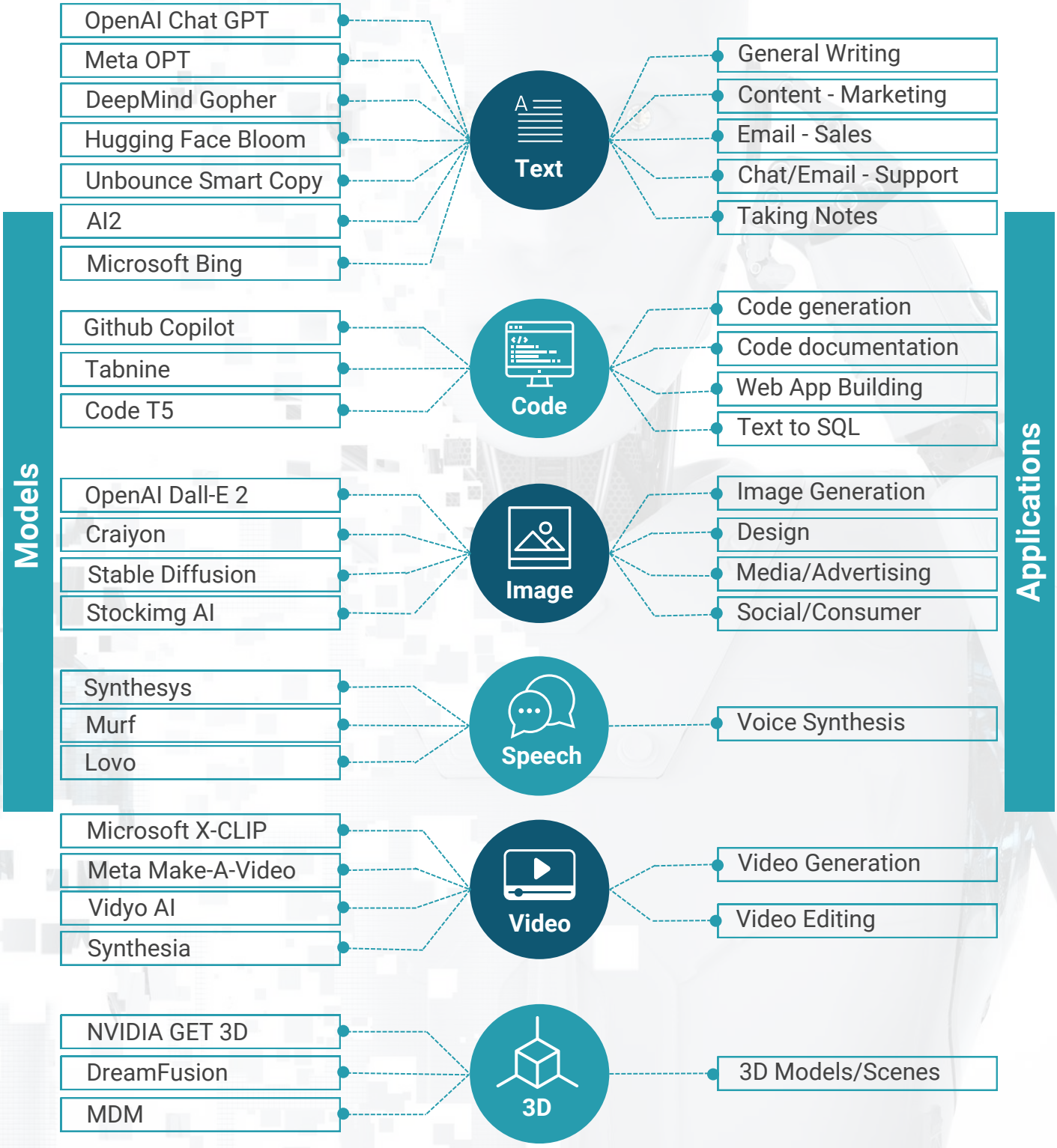
- Extracts information from human emotions - expressions, speech
- Collects and analyzes data using sensors and hardware
- Applications are wearables, smart home devices, etc.

Decision AI

- Accurate decision making using ML and optimization algorithms
- Ability of reasoning and prediction like humans
- Applications are supply chain management, healthcare, etc.

Generative AI Landscape

Generative AI is a field of artificial intelligence that focuses on generating original and new content, instead of just analyzing and processing existing data. It falls under the broad category of machine learning (ML) and uses algorithms enabling machines to create artificial yet fresh content.



Growth Drivers of AI

Availability of extensive data

Free flow of data from government, businesses and research institutions are creating ample opportunities for research and assisting in solving complex problems by training AI models. Rapid digitization, extensive use of the internet and smartphones are adding value and generating large volumes of data.

Processing power

Graphical Processing Units, cloud computing and a new set of dedicated processors have changed the landscape of computing architecture. Such tech developments are fueling the adoption of AI in many fields, leading to the increased computing power of processors.

Growing focus on industrial challenges

Many businesses are increasingly making larger investments into AI to translate to significant business value outcomes and applying to resolve domain specific industrial challenges, paving the way for widespread industrial AI adoption.

Tech-savvy population

India has a major chunk of the population that is increasingly adopting technology in their everyday lives. Besides, the diversified tech market of India is accommodating a broad range of requirements and the nation has become a hub for global design and development of products, powered by AI.

Growing startups

India boasts of a thriving startup ecosystem comprising 1900 AI focussed startups that has increased focus on the development of AI-based solutions. Interestingly, AI startups increased 14 times from 2000 and investments tremendously increased by 6 times.

Increasing investments

Along with the Government, private investors are also investing heavily in AI and its development. Such investments are creating opportunities for new jobs and innovation, to strengthen digital capabilities and also to position businesses to compete on a global scale.

Economical talent pool

Our country has a big talent pool of data scientists and engineers with skills in developing AI technologies. These professionals can be hired at relatively lower costs in India when compared to other countries.

AI Landscape across Major Industries

Industry	Market Size	Key Job Roles	Application
 **Healthcare**	AI in the Indian healthcare industry is estimated to grow at a CAGR of 50.9% AI expenditure in India is expected to reach $11.78 bn by 2025 and is expected to add $1 tn to India's economy by 2035	• Clinical Data Analyst • Medical Imaging Specialist • Health Informatics Analyst • Clinical Decision Support Specialist • Telemedicine Specialist • Healthcare Robotics Engineer	• Virtual health assistants • Telemedicine • Automation of redundant healthcare tasks • Customer service chatbots • Management of medical records • Robot-assisted surgery • Reduction of dosage errors • Accurate cancer diagnosis • Early diagnosis of fatal blood diseases • Treatment of rare diseases • Targeted treatment • Automated image diagnosis • Clinical trial participation • Development of new medicines
 **Education**	AI in education market size is at an estimated revenue of $ 2.1 bn in 2022. During 2022–2030, the growth rate of AI in the education market will be around 36.6%	• Edtech Product Manager • AI Learning Architect • AI Curriculum Developer • Educational Data Scientist • Chatbot Developer • Educational Researcher • Instructional Designer • Learning Experience Designer	• Personalized learning • Smart content creation • Task automation • Universal access • Virtual learning environment • Secure and decentralized learning system • Grading software • Admin tasks

 **BFSI**	India is one of the rapidly growing markets for BFSI globally. The sector is undergoing a huge digital transformation with a consumer base of 600 mn tech-savvy users along with favorable policies by the government. AI has a potential to add a revenue of $60 bn to the BFSI sector by the year 2026 by offering targeted services and redefining user experience. The BFSI sector has a market share of AI services at 9.6% approximately 65.2 mn.	• Chatbot Developer • Fraud Analyst • Credit Risk Analyst • Investment Analyst • Compliance Specialist • Customer Experience Analyst	• AI chatbots • Data collection • Data analysis • Portfolio management • Risk management • Cybersecurity and fraud detection • Regulatory compliance • Tracking of market trends • Predictive analytics • Process automation
 **Manufacturing**	Breakthrough technology to achieve 25% sectoral contribution to Indian economy, pegged at $1 tn by 2025. ▪ Potential to increase AI spend from 5% (percentage of digital tech spend) to at least 10% ▪ 78% of manufacturers in India have defined AI strategies	• Industrial Data Scientist • QC Analyst • Process Automation Specialist • Predictive Maintenance Engineer • Robotics Engineer • Supply Chain Optimization Specialist • Inventory Management Analyst	• Manufacturing process automation • Logistics • Predictive maintenance • Product development and design • Quality assurance • Supply chain management • Supply chain forecasting • Inventory management • Forecasting product demand • Anomaly detection
 **Retail**	India is world's one of the Top 5 retail markets, to grow to $1.4 tn by 2024 ▪ 3X growth is expected to bring mass-scale data and AI-led disruption ▪ CX, operational efficiency and revenue growth top priority areas	• Retail Data Analyst • IT Process Modeler • Digital Imaging Leader • Customer Experience Leader • Deep Learning Consultant	• Real-time pricing optimization • Personalized recommendations • Demand prediction • Supply chain optimization • Inventory management • Sales forecasting • Fraud detection • Customer retention • Intelligent automation

Business Benefits of AI

Artificial intelligence may not yet be able to replace human intelligence, but it is highly capable of processing large amounts of data and making faster analysis than humans can. If used to its best potential, AI can help businesses greatly. There are several reasons why companies should adopt AI, some of them are:

Challenges in Adopting & Implementing AI for Businesses

AI adoption

Small and Medium Enterprises (SMEs) face greater disadvantage in terms of AI adoption as they divert their internal resources to administer functions, than large firms. Issues like data complexity needs data science led pyramid of skills and pre-built solutions and talent scarcity are huge challenges for SMEs.

Data complexity

Industrial AI systems are driven by sensor data, and their AI validation represents noisy datasets that create an inconvenience to store and analyze, necessitating a lot of clean and training data sets, which pose problems in completing AI projects for smaller enterprises.

Higher dependency on niche skills and AI expert talent

With the rapid advancement in tech, the AI sector has massive requirements for skilled professionals. Data indicates 80% of Indian engineers do not possess the skills required to meet the demands of employers.

Higher costs

Businesses that lack in-house skills and infrastructure have to highly depend on the outsourcing channel to incur costs. Moreover the cost for computing training data models comes up as an additional expense.

Infrastructure and computing power

Using AI requires power-hungry algorithms with an increasing need of efficient cores and GPUs. This need for high computing power and storage can pose a significant challenge for businesses deploying AI systems.

Data privacy

With data being generated from all over the network and millions of users, there are high chances of data being misused. In such cases, confidential and sensitive data is subject to privacy vulnerabilities and security breaches.

Ethical concerns

With adoption of AI comes certain ethical concerns such as privacy, transparency, and bias. These issues can make it difficult for businesses to employ effective and ethical AI solutions.

iCET - Forces Shaping Future of Technology - Artificial Intelligence

Government Initiatives on AI

- FutureSkills Prime, a collaboration of MeitY and NASSCOM extends upskilling and reskilling opportunities to IT professionals in emerging areas like AI. As of March 2022, 7L candidates signed up for this program
- A first-of-its-kind report launched by Niti Aayog 'National Strategy for Artificial Intelligence' in 2018
- Launched National AI portal, repository of AI-initiatives in the country. As of today there are 871 news articles, 1826 articles, 132 research reports, 284 videos, 184 Govt. Initiatives, 287 startups listed on the portal
- Launched the National Programme on Responsible Use of AI for Youth to create AI awareness in Government schools
- The 'Visvesvaraya PhD Scheme' was launched by the government to enhance the research areas of AI along with other fields listed
- Established 25 Technology Innovation Hubs in the reputed institutions as part of the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS) to stimulate AI innovation
- A National Programme on AI has been initiated to offer benefits of AI and related technologies to people in Nine identified priority areas - Healthcare, Education, Smart Cities, Energy, Finance, Agriculture, Cyber Security, Indian Languages, and Transportation

Future of Workforce with AI

The overall impact of AI on the future of the workforce is expected to be significant in terms of creating new opportunities and skills.

- The adoption of AI has the power to automate repetitive tasks, reduce errors and improve efficiency and productivity, helping people perform better
- With almost all companies implementing AI in their processes and solutions, there will be continued demand for skilled workforce
- In order to be prepared for the AI-automation era, the workforce must upskill themselves to stay relevant in the industry. The required AI skills are no longer confined to the tech sector and have widespread applications in healthcare, manufacturing, automotive, retail, banking and other industries
- Educational bodies have migrated from their traditional curriculum and incorporated new age technologies in their courses. There are many academic institutes that have collaborated with industries and top universities to offer both classroom and online courses on AI and AI-related topics

~ 45k

Open jobs in AI as of Feb 2023

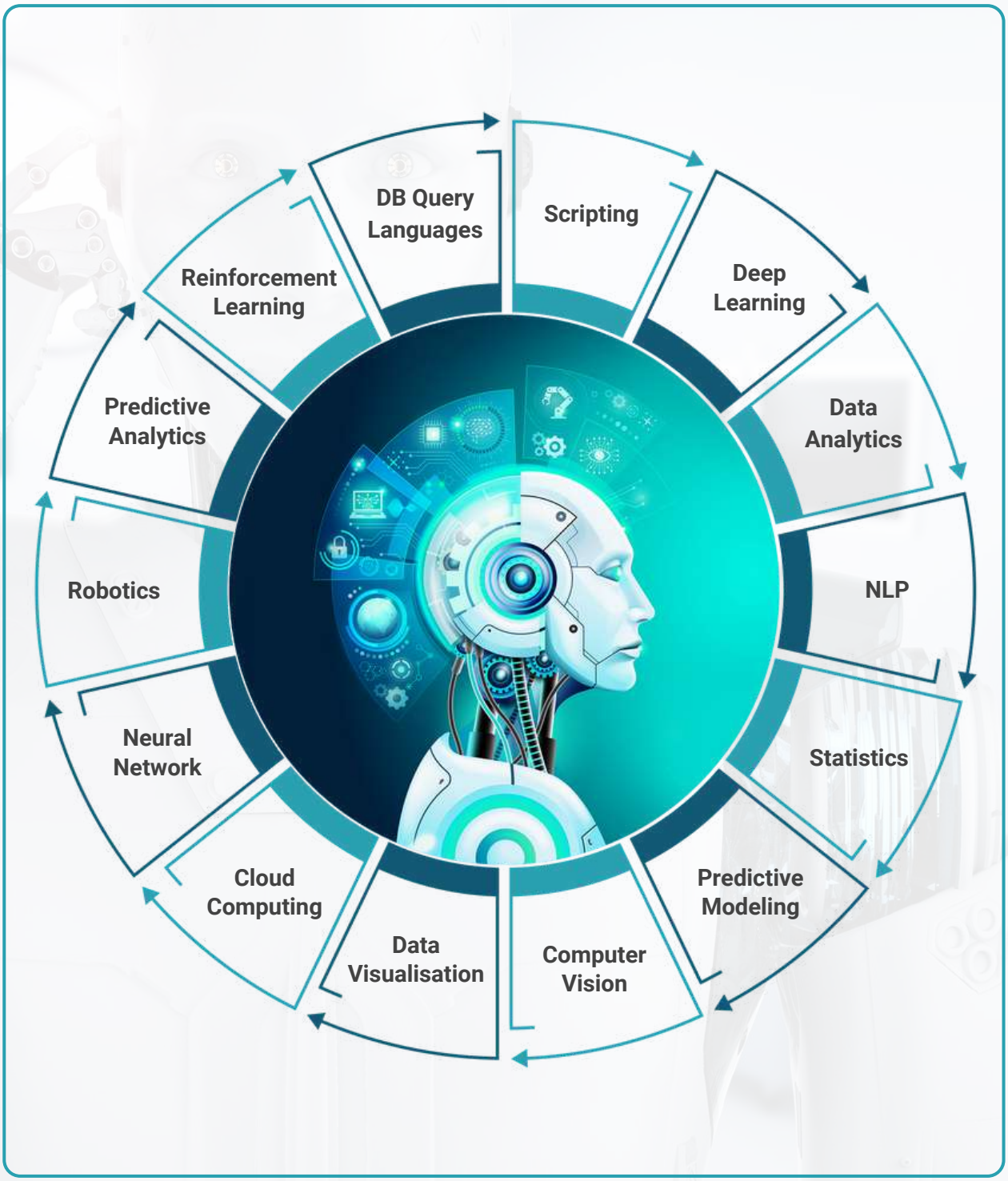
Data Scientists and ML Engineers are popular roles in AI

"Youngsters or employees seeking promising careers in Critical and Advanced Technologies like AI must focus on upskilling their skills which will give them ample opportunities in the dynamically changing tech landscape "

Siva Prasad Nanduri
Chief Business Officer, TeamLease Digital

Essential AI skills in Demand

With increasing focus on scalable ML applications, the demand for software engineers and data professionals will eventually go down. This will lead to an increase in demand for AI professionals proficient in scripting languages. More and more AI professionals will have to learn building ML solutions and the basic skill of building conventional ML models will be the foremost skill required for having a career in AI.



Upskilling for Career Advancement in AI

Freshers aspiring to pursue a career in AI must have passed class XII with physics and math and should have completed a course/graduation in the required discipline based on the job requirement. It is important to have a strong foundation in math including topics of linear algebra, statistics and calculus.

Experienced professionals can enrol for online or classroom courses and build a foundation in ML, deep learning, NLP, data analysis, and computer vision. They can upskill themselves in AI through a combination of obtaining knowledge, gaining practical experience, obtaining certifications as well as staying up-to-date with the latest trends.

Job Roles for Freshers

- Software Engineering
- Data Analyst
- Application Developer
- Business Analyst
- Statistical or Quantitative Analyst
- Operations Research Analyst

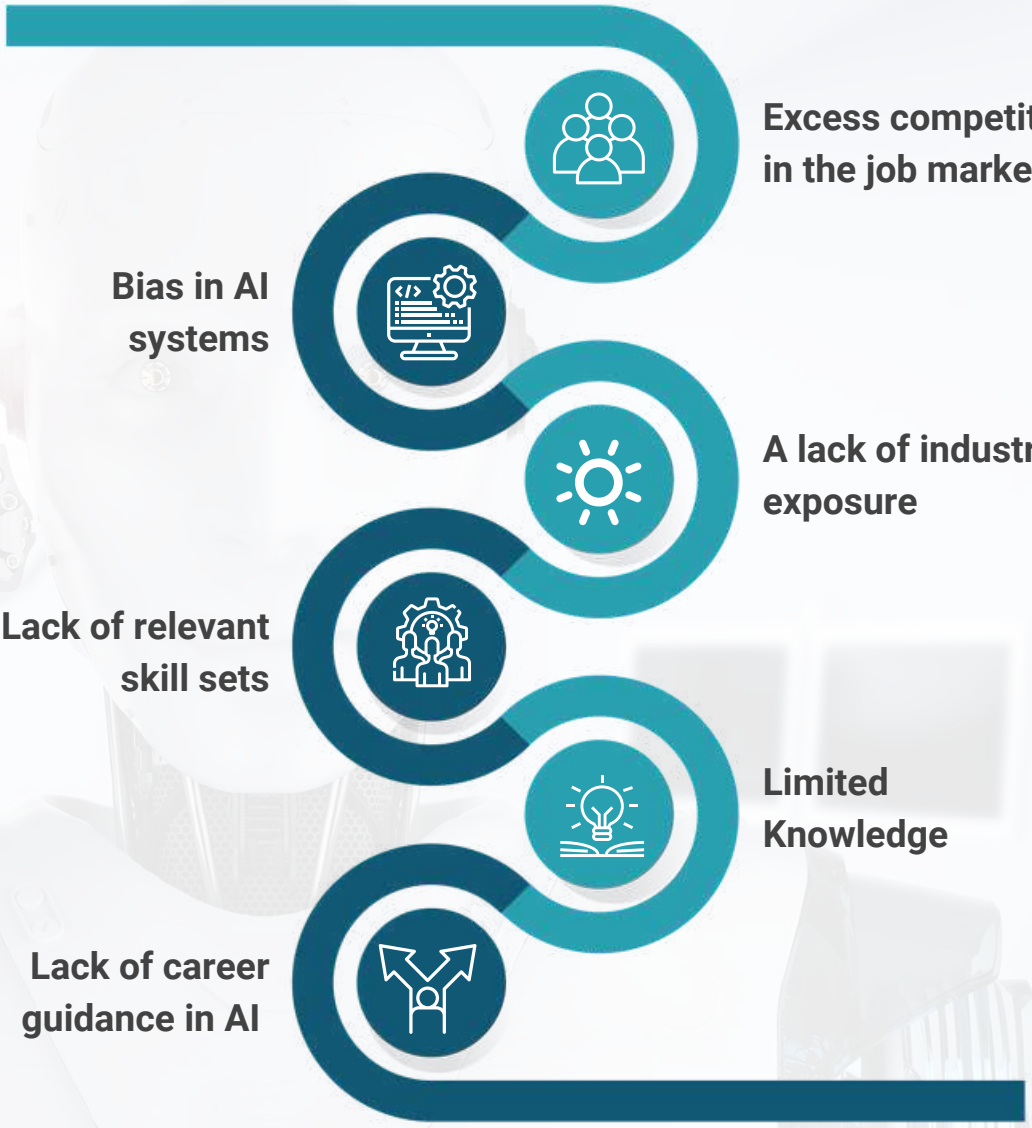
Job Roles for Experienced

- Machine Learning Scientist
- NLP Engineer
- Machine Learning Engineer
- Image Processing Engineer
- Data Scientist

Popular AI Roles and Salary Range

Role	Salaries by experience			
	0 - 3 Yrs	3 - 5 Yrs	5 - 8 Yrs	8+ Yrs
Data Engineer	3L - 14L	8L - 19L	17L - 25L	25L - 45L
ML Engineer	2.5L - 10L	11L - 17L	17L - 24L	24L - 40L
Data Scientist	3.5L - 14L	12L - 19L	17L - 27L	23L - 32L
Devops Engineer	3L - 12L	12L - 17L	17L - 23L	18L - 27L
Data Architect	3L - 12L	12L - 18L	20L - 35L	25L - 40L
BI Analyst	3L - 14L	8L - 18L	17L - 25L	23L - 40L
Database Admin	3L -12L	12L - 15L	15L - 20L	20L - 25L

AI Career Challenges

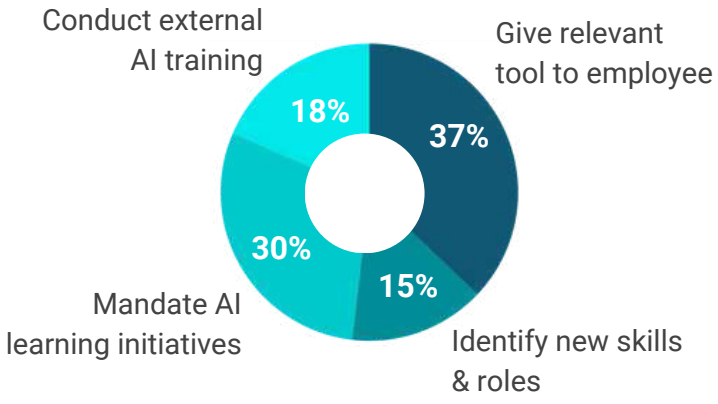


"As AI is on the verge of creating multiple job opportunities in the labour market, it is essential for job aspirants to master AI skills in a timely manner to stay competitive in the job market."

Krishna Vij
BU Head - IT Staffing, TeamLease Digital

Additional Survey Findings by TeamLease Digital

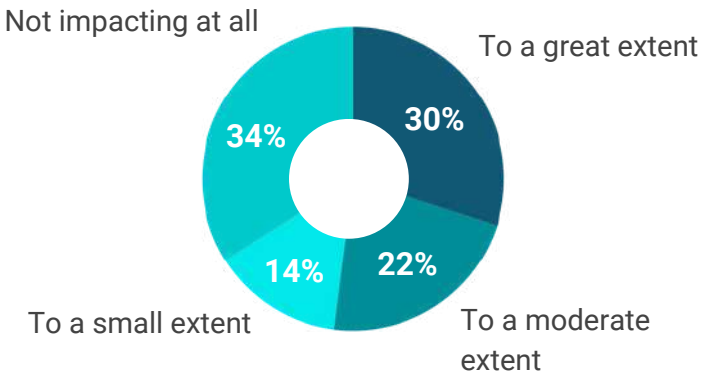
Strategy organisations should follow to build AI-ready workforce



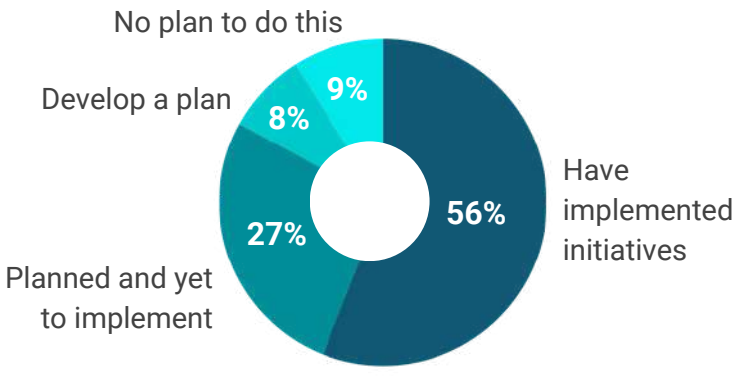
Organisations feel giving relevant tools and providing learning initiatives to employee will help build a AI ready workforce

Impact of current job market on company AI initiatives

Most organisations feel job market has some or the other impact on their AI initiatives

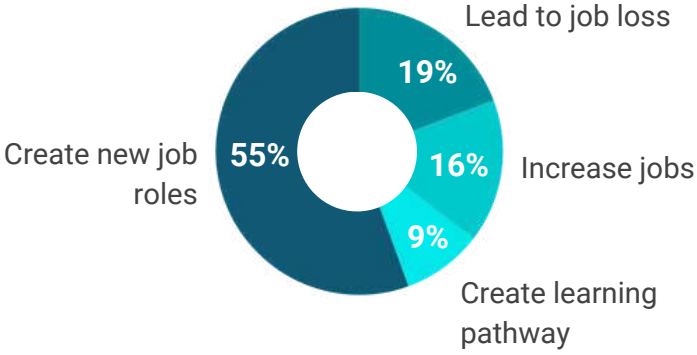


Readiness of organisations to fill AI demand supply talent gap



Most organisations feel that AI will help unlock hidden talent in the workforce

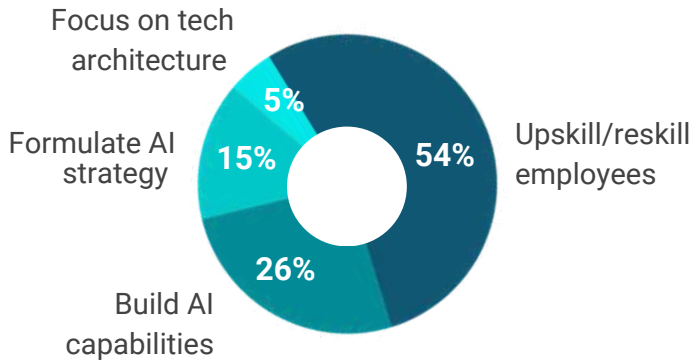
Impact of AI on job market



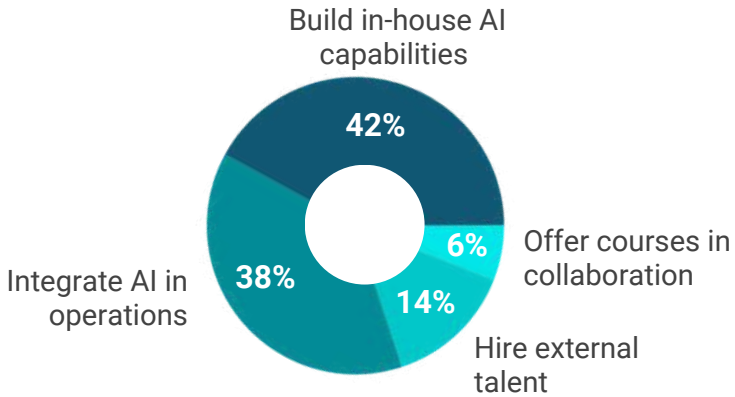
Most employees feel AI will unlock new job opportunities

AI Initiatives that organisations should pursue

Most Employees feel organisations need to upskill / reskill employees



Initiatives that can enhance AI capabilities of an organization



Most employees feel building in-house capabilites and integrating AI in daily operations will enhance AI capabilites

What Experts Say about AI?

“AI is set to create close to 20-25 million jobs in the next 3-5 years. Job seekers need to upgrade their skills according to market shaping to make sure they are on the right path. We can expect a lot of opportunities for NLP engineers, Programmers, AI Product Managers, Robotic Engineers, Data Scientist, and Research Scientists.”

Hariprasad Padaki - Head of Vision Care Operations, Carl Zeiss

"Artificial Intelligence is playing a significant role in helping businesses improve their digital quality and achieve their digital transformation goals. Some of the ways AI is doing this include automating quality assurance, providing predictive analytics, using chatbots and virtual assistants to improve customer service, personalizing marketing messages, and detecting and preventing fraud. By leveraging AI-powered tools and technologies, businesses can streamline their operations, improve customer experiences, and stay ahead of the competition in today's digital age."

Radhika Rao - Chief Delivery Officer, Kairos Technologies Inc.

“There are several benefits of integrating AI in business operations, some of which are increased productivity, improved decision making, personalized customer experience, saving operational costs as it takes shorter time and need lesser number of people to get a job done; thereby giving competitive advantage to organizations adopting AI over their competitors.“

Navin Patel - Global TA Head, Affine

Conclusion

The iCET initiative is promising and timely, given how CETs are transforming an overall economic and security landscape as it is expecting an adverse range of twenty-five joint research projects which covers AI extensively. The initiative extends both India and the US a real opportunity to grow together by enhancing bilateral relationships. In the long run the initiative not only secures technological progress but also ensures the capacity building of individuals and institutions in emerging technological areas extending an opportunity to India to become a global technological power and the powerhouse of global tech talent.

Appendix - CET

No.	Technology	Description	Key Subfields	Use Cases
1	**Advanced Computing**	The term 'advanced computing' describes the application of complex computer tools and processes that go beyond conventional computing practices. This encompasses innovations like big data analytics, artificial intelligence, machine learning, and high-performance computing.	• Supercomputing • Edge computing • Cloud computing • Data storage • Computing architectures • Data processing and analysis techniques	Self-driving cars, personalized medicine, weather forecasting, financial modeling
2	**Advanced Engineering Materials**	It refers to a class of materials specifically designed to inherit physical, chemical, and mechanical properties and is more efficient than the conventional material.	• Materials by design and material genomics • Materials with new properties • Materials with substantial improvements to existing properties • Material property characterization and lifecycle assessment	**Aerospace & Aviation:** Carbon Fiber Reinforced Polymers (CFRP), Titanium **Electronics:** Graphane, Nanomaterials, Organic semiconductor **Medical implant:** Bioactive glasses, ceramics, polymers
3	**Advanced Gas Turbine Engine Technologies**	The recent advancements in gas turbine engine design, production, and operation are referred to as advanced gas turbine engine technology.	• Aerospace, maritime, and industrial development and production technologies • Full-authority digital engine control, hot-section manufacturing, and associated technologies	High temperature materials, combustion control, 3D printing, Advanced cooling systems
4	**Advanced Manufacturing**	It refers to the latest and innovative techniques and technologies that are used to improve the manufacturing process.	• Additive manufacturing • Clean, sustainable manufacturing • Smart manufacturing • Nanomanufacturing	Robotics and automation, 3D printing, Smart manufacturing, Sustainable manufacturing
5	**Advanced and Networked Sensing and Signature Management**	It is indicative of the techniques and technologies used to collect and analyze data from various sources to identify and track objects and people.	• Payloads, sensors, and instruments • Sensor processing and data fusion • Adaptive optics • Remote sensing of the Earth • Signature management • Nuclear materials detection and characterization • Chemical weapons detection and characterization • Biological weapons detection and characterization • Emerging pathogens detection and characterization • Transportation-sector sensing • Security-sector sensing • Health-sector sensing • Energy-sector sensing • Building-sector sensing • Environmental-sector sensing	Signature reduction, autonomous sensing system, hyperspectral imaging, distributed sensor network
6	**Advanced Nuclear Energy Technologies**	It refers to innovative approaches to nuclear energy that are safer, sustainable, and cost effective.	• Nuclear energy systems • Fusion energy • Space nuclear power and propulsion systems	Medical imaging, cancer treatment, space exploration, hydrogen production, synthetic fuels

No.	Technology	Description	Key Subfields	Use Cases
7	**Artificial Intelligence**	AI refers to simulation of human intelligence process by machines to tackle issues traditionally solved by human intelligence.	• Machine learning • Deep learning • Reinforcement learning • Sensory perception and recognition • Next-generation AI • Planning, reasoning, and decision making • Safe and/or secure AI	Automated customer service, chatbots, voice search, smart home control, digital assistant, e-payment
8	**Autonomous Systems and Robotics**	Autonomous system and robotics refer to development of intelligent machines to operate without human intervention.	• Surfaces • Air • Maritime • Space	Crop monitoring, harvesting, unmanned vehicles and drones, surgical robots, telepresence robots
9	**Biotechnologies**	Effective use of biological processes, organisms and systems to develop new technologies is known as biotechnology.	• Nucleic acid and protein synthesis • Genome and protein engineering including design tools • Multi-omics and other biometrology, bioinformatics, predictive modeling, and analytical tools for functional phenotypes • Engineering of multicellular systems • Engineering of viral and viral delivery systems • Biomanufacturing and bioprocessing technologies	Gene therapy, cell therapy, biofuels, DNA sequencing, Bioremediation
10	**Communication and Networking Technologies**	It eases communication and information exchange between individuals and systems.	• Radio-frequency (RF) and mixed-signal circuits, antennas, filters, and components • Spectrum management technologies • Next-generation wireless networks, including 5G and 6G • Optical links and fiber technologies • Terrestrial/undersea cables • Satellite-based communications • Hardware, firmware, and software • Communications and network security • Mesh networks/infrastructure independent communication technologies	5G, IoT, Cloud Computing, AR/VR, Social media platforms
11	**Directed Energy**	Directed energy uses electromagnetic radiation to achieve specific effect on the target.	• Lasers • High-power microwaves • Particle beams	Laser weapons, high-powered microwaves, Directed Energy Propulsion
12	**Financial Technologies**	FinTech uses technology to automate and improve financial services effectively.	• Distributed ledger technologies • Digital assets • Digital payment technologies • Digital identity infrastructure	Crowdfunding, digital payment, robo-advisory services, cryptocurrency exchanges
13	**Human-Machine Interfaces**	It includes tools and technologies to facilitate communication between humans and machines.	• Augmented reality • Virtual reality • Brain-computer interfaces • Human-machine teaming	Touchscreen, virtual assistant, gesture recognition, AR systems

Sl No.	Name of Technology	Description	Key Subfields	Use Cases
14	**Hypersonics**	It deals with study of flights at high-speed and has potential to revolutionize air travel and military technologies.	• Propulsion • Aerodynamics and control • Materials • Detection, tracking, and characterization • Defense	Space transportation, high-speed commercial vehicle, high-speed missiles
15	**Networked Sensors and Sensing**	It includes a group of sensors interconnected with each other to collect and study the data in real-time.		Environment monitoring, patient vitals monitoring, manufacturing line monitoring
16	**Quantum Information Technologies**	It uses theory of quantum mechanics to store, process and share information.	• Quantum computing • Materials, isotopes, and fabrication techniques for quantum devices • Post-quantum cryptography • Quantum sensing • Quantum networking	Quantum computing, quantum cryptography, quantum algorithms
17	**Renewable Energy Generation and Storage**	It is used as alternative electricity generating system that allows energy to be stored and released as per the requirement.	• Renewable generation • Renewable and sustainable fuels • Energy storage • Electric and hybrid engines • Batteries • Grid integration technologies • Energy-efficiency technologies	Wind power system, water power system, solar photovoltaic
18	**Semiconductors and Microelectronics**	Semiconductors are used between conductor and insulator to enable electrical conductivity. Microelectronics is study and application of small scale electronic devices and circuits.	• Design and electronic design automation tools • Manufacturing process technologies and manufacturing equipment • Beyond complementary metal-oxide-semiconductor (CMOS) technology • Heterogeneous integration and advanced packaging • Specialized/tailored hardware components for artificial intelligence, natural and hostile radiation environments, RF and optical components, high-power devices, and other critical applications • Novel materials for advanced microelectronics • Wide-bandgap and ultra-wide-bandgap technologies for power management, distribution, and transmission	Integrated circuits in smartphones, devices and computers
19	**Space Technologies and Systems**	These technologies are used widely in space explorations and utilization	• On-orbit servicing, assembly, and manufacturing • Commoditized satellite buses • Low-cost launch vehicles • Sensors for local and wide-field imaging • Space propulsion • Resilient positioning, navigation, and timing (PNT) • Cryogenic fluid management • Entry, descent, and landing	Earth observation, weather forecasting, launch vehicles, spacecraft, climate monitoring

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