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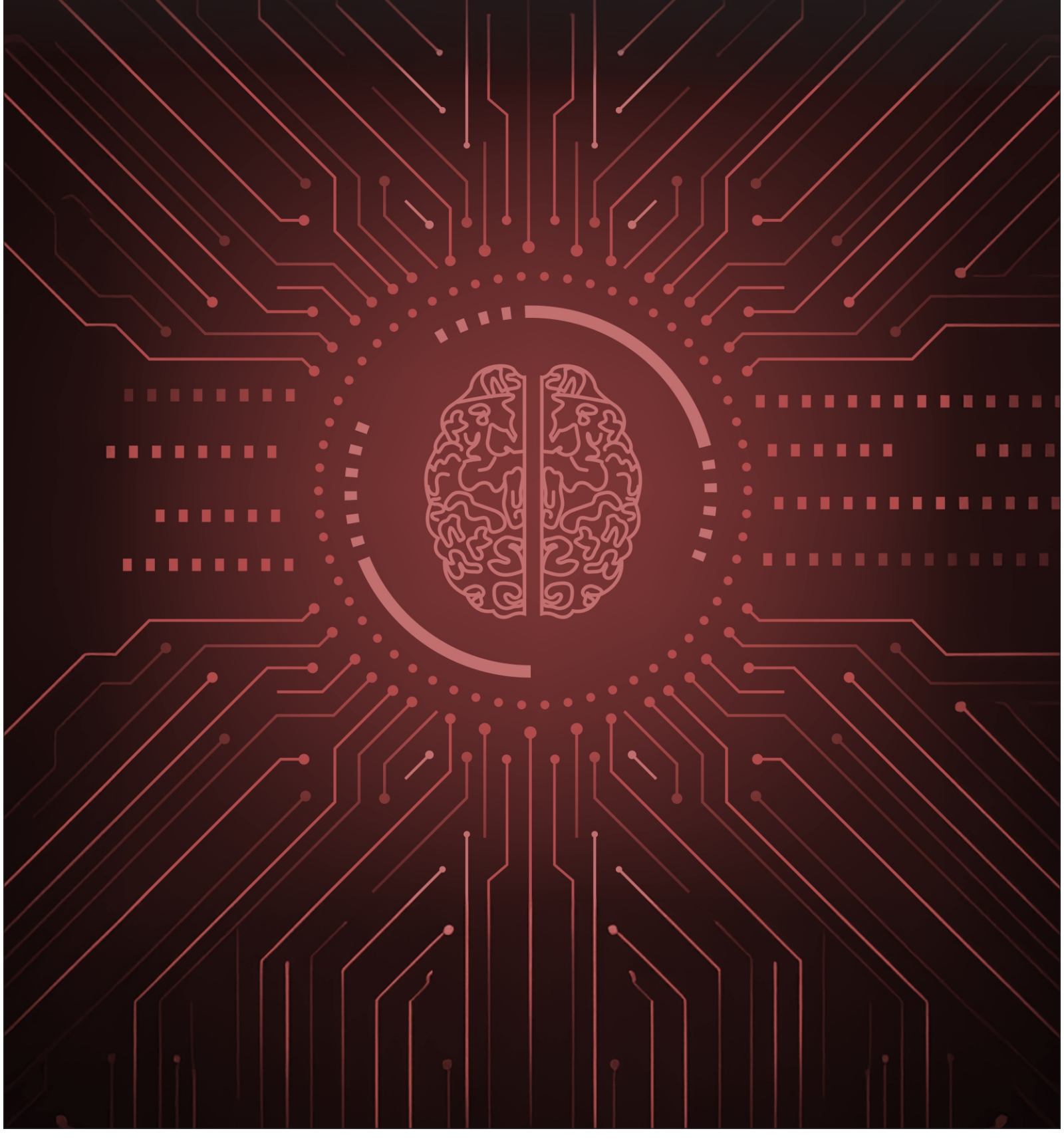
Strategic Applied AI Research: Top 20 Challenges for India's Innovation Ecosystem



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Objective

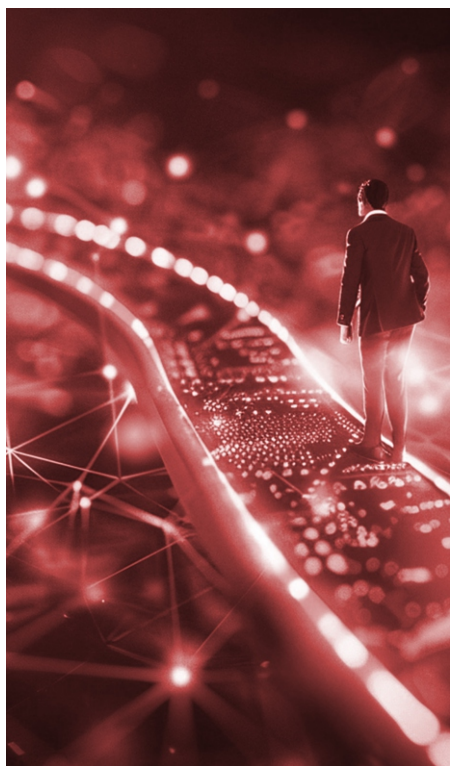
The rapid evolution of AI presents both **opportunities and challenges**, requiring research efforts that bridge **academic advancements with real-world applications**. This report identifies **20 high impact applied AI research topics** that address **pressing industry needs, technological gaps, and future AI development pathways**.

Through this report, the readers will:

- **Explore the latest developments** in emerging AI research fields, to stay informed about the advancements shaping the future of AI.
- **Understand industry-validated research priorities**, ensuring alignment with real-world applications and evolving technological needs.
- **Explore innovative AI methodologies**, including alternative neural architectures, synthetic data generation, and scalable AI models.
- **Identify collaboration opportunities** between researchers, startups, enterprises, and policymakers to accelerate AI-driven advancements.
- **Leverage these findings to shape AI strategies, investments, and product development efforts**, driving meaningful impact across sectors.

By focusing on these applied AI topics, this report serves as a **strategic guide for AI stakeholders**, equipping them with the knowledge to **navigate the evolving AI landscape and contribute to impactful innovation**.

Executive Summary



Nasscom is committed to **boosting India's AI innovation footprint** by encouraging **advanced research that leads to impactful publications** in leading global venues and the **development of open-source AI toolkits.** This effort is focused on fostering **collaborative research on cutting-edge applied AI,** bringing together **startups, Indian AI labs, academia, industry, and policymakers.** The goal is to **bridge the gap between academic research and real-world AI applications,** ensuring that innovation translates into **practical, scalable solutions that benefit industries and society.**

Scope and Approach

This document outlines key applied AI research topics identified by the Nasscom AI team, carefully selected to address critical challenges and opportunities in AI adoption. These topics have been validated through consultations with startups and enterprises to ensure alignment with market needs. Based on this process, a curated list of **20 high impact applied AI research topics** has been developed, serving as a **blueprint for India's applied AI research agenda.**

Key Applied AI Research Topics

The **20 selected applied AI research topics** are categorized into **six key research themes**, each addressing critical AI challenges and opportunities:

AI for Security and Trust

With rising threats from **deepfakes, synthetic voices, and data privacy issues,** ensuring AI security is essential. Research areas include:

Deepfake Detection & Mitigation – Enhancing models to detect AI-generated fake content.

Fake Voice Detection & Privacy – Developing better fake voice detection and secure watermarking techniques.

Machine Unlearning & Data Erasure – Enabling AI models to "forget" sensitive data for privacy compliance.

Multimodal & Context-Aware AI

As AI processes diverse data types (e.g., text, speech, images, videos), ensuring alignment across modalities is crucial. This theme explores:
Multimodal AI & Content Moderation - Enhancing model quality, interpretability, and reducing biases for fair, accurate content moderation.

Contextual Ambiguity & Cultural Adaptation - Addressing slang, dialects, sarcasm, and linguistic nuances.

Synonyms & Semantic Variability - Enhancing AI's ability to handle diverse language expressions.

Advancing AI Architectures & Efficiency

Traditional AI architectures face scalability and efficiency issues. Research focuses on:
Beyond Transformers (Sub-quadratic Sequence Modeling) – Exploring scalable, efficient AI models.

Trainable Activation Functions – Improving learning efficiency in neural networks.

Novel AI Without MatMul Operations – Developing energy-efficient computational frameworks.

Physics-Driven Generative Models – Applying physics constraints to generative AI for scientific accuracy.

AI for Speech & Vision

AI must improve in handling underrepresented languages, diverse viewpoints, and accessibility. Key topics include:
ASR for Under-Represented Languages – Enhancing speech-to-text models for low-resource languages.

Neural Speech Synthesis from Brain Signals – Advancing AI-driven speech for people with disabilities.

Viewpoint Variation in Computer Vision – Improving AI adaptability to different visual perspectives.

Responsible AI & Bias Mitigation

Ensuring fairness, transparency, and bias reduction in AI systems is critical. This research theme includes:
Bias, Interpretability & Fairness in Foundation Models - Improving explainability and fairness in AI models.

Bias in Recommendation Systems - Developing real-time bias mitigation strategies in Recommendations.

Synthetic Data Generation - Creating diverse, privacy-compliant datasets for AI training.

AI in Creative & Scientific Applications

AI is transforming creative industries and scientific research. Focus areas include:

AI in Video Production - Automating video editing and content generation.

CRISPR + LLMs/Graphs for Agriculture & Environment – Combining gene editing with AI for precision agriculture and environmental applications.

By anchoring AI research around these applied topics, Nasscom aims to cultivate a thriving AI ecosystem that integrates applied research with market needs. Nasscom is eager to drive this collaborative effort, positioning India as a global leader in AI innovation.

Context

India's AI landscape holds immense potential, but to truly maximize its impact, the country needs to significantly increase its global research influence and foster indigenous AI innovation. To achieve this, Nasscom is proposing a framework to reshape India's AI innovation landscape.

This framework focuses on enhancing India's global AI research presence through two key mechanisms. First, it aims to generate high-impact research publications in prestigious international venues, establishing India's thought leadership in AI. Second, it focuses on developing open-source AI toolkits, which will provide practical resources for the broader technology community.

Central to this is the establishment of a dedicated AI research platform for collaborative research. This platform will serve as a central hub for the entire AI ecosystem encompassing startups, Indian AI labs, academia, industry, and policymakers.

The primary aims are:

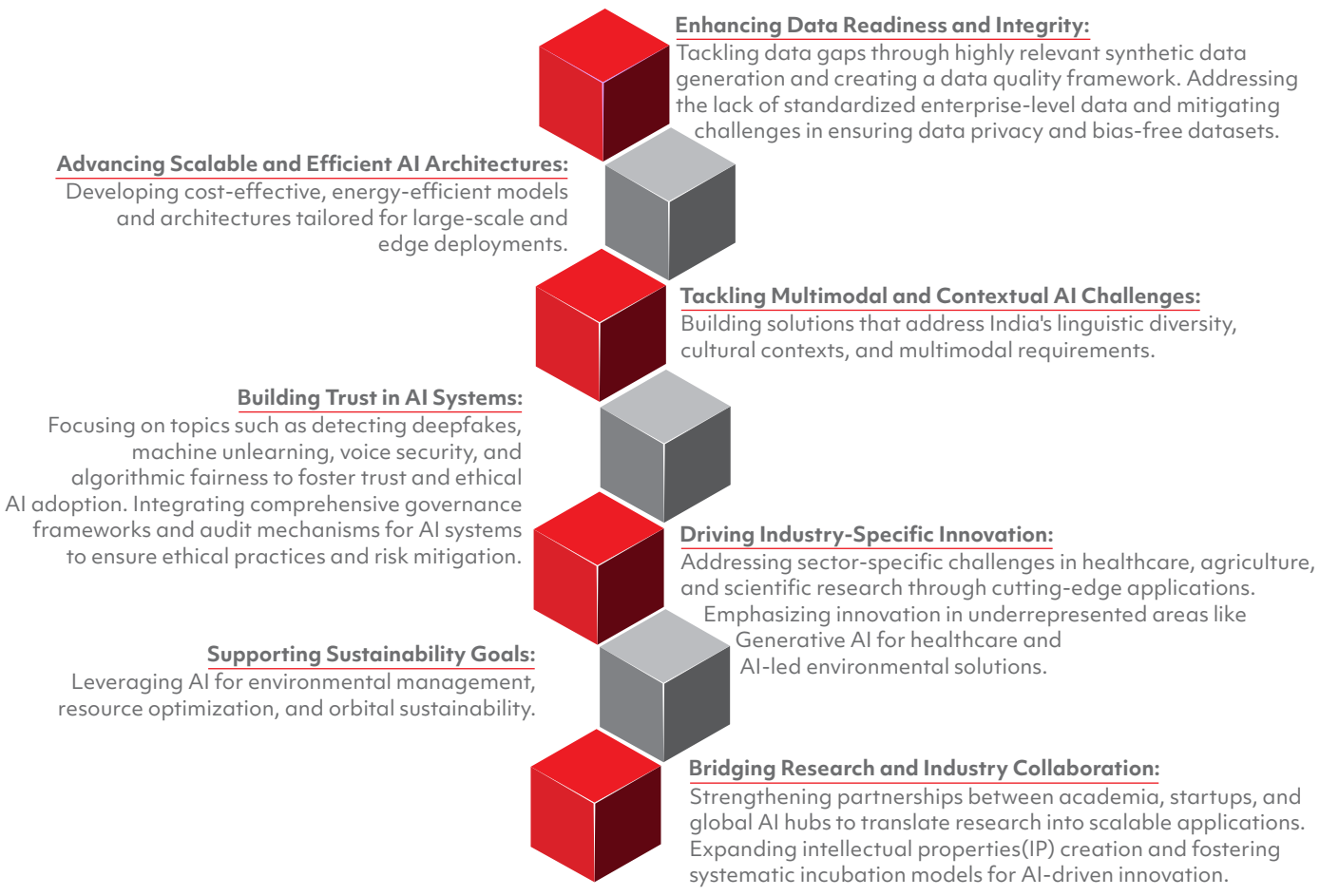
- **Joint Research Projects**: The partners will collaborate on jointly defined research agendas from any AI topic as identified by Nasscom. This will enable the sharing of knowledge and resources, leading to more efficient and impactful research outcomes.
- **Industry Partnerships:** Partnering with industry leaders to provide real-world datasets, challenges, and funding opportunities for the research collaborations. This will ensure that AI research is relevant and applicable to industry needs.
- **Student Exposure:** The collaboration will facilitate students with valuable industry experience and exposure to real-world AI challenges, while also benefiting the start-ups and/or Indian AI Labs by tapping into the latest academic research.
- **Technology Transfer:** The partners will explore opportunities for developing open-source AI toolkits. This will ensure that the research has a tangible impact on society and the economy.
- **Co-authored Publications:** The partners will collaborate on academic publications, disseminating their research findings to the broader scientific community. This will enhance the visibility of all engaging institutions and contribute to the advancement of AI research.

Building Blocks for an Impactful Research

India's AI landscape has seen steady growth, but there remains a critical need to enhance the country's global research impact and strengthen indigenous AI innovation. Building on this foundation, Nasscom has identified priority areas to address pressing challenges in the AI ecosystem, aligning with the objectives of advancing research, fostering collaboration, and creating impactful solutions.

The goal is to support the Indian AI ecosystem and the broader AI community in systematically addressing real-world problems while propelling India towards its aspiration of becoming a global leader in AI. Key gaps hindering India's AI progress include fragmented data quality frameworks, which limit the development of reliable AI solutions, and weak collaboration between research institutions, startups, and industries, stalling scalable innovation and impactful adoption. Additionally, insufficient innovation to tackle domain-specific challenges like healthcare and sustainability, coupled with the need for more contextual use cases tailored to India's unique linguistic and cultural diversity, impede progress. By addressing these gaps, research and innovation can align with India's industrial priorities and societal needs, as highlighted by the Enterprise AI Adoption Index 2.0 ensuring the delivery of practical solutions with tangible impact. This alignment not only advances industrial capabilities but also effectively meets critical societal demands.

The following building blocks have been identified to address India's AI challenges:



These building blocks collectively aim to make AI solutions scalable, inclusive, and impactful, positioning India as a global AI leader. He next step is to select applied AI research topics based on these building blocks. This is described next.

Selection Procedure

The focus was on identifying applied AI research topics that are highly relevant for the Indian AI ecosystem, both in terms of immediate impact and long-term innovation potential. The problems selected were based on short-to medium-term research goals (1-3 years) and focused on areas with high societal and economic value.

Problem Identification Process:

Extensive Desk Research: Nasscom AI team conducted an in-depth review of the last three years of top-tier AI conference papers, journals, tutorials, keynote talks, reports from research grant agencies (both Indian and international) and think tanks. This ensured that the problems selected reflect the latest advancements in AI.

Startup Engagement: The list of identified problems was then shared with the Nasscom Startup Foundry cohort. Startups were asked to rate the relevance of these problems on a scale from 1 to 5, with 5 being the highest. This ensured that the problems were aligned with the immediate and practical challenges faced by startups.

Relevance Rating and Feedback: In addition to rating, startups provided feedback, proposing new problems or refining the scope of the existing ones. The startup founders' insights were particularly valuable in ensuring that the research problems remained practical and directly applicable to the market.

The problems were then prioritized based on the following criteria:

Impact on the Indian Ecosystem: The problems that could drive significant economic, social, or environmental impact were given higher priority.
Feasibility: Problems that can be tackled within the next 1-3 years, either through existing methodologies or emerging innovations, were prioritized.

Global Relevance: While the problems are rooted in the Indian context, their solutions should have global relevance, enabling Indian startups/AI Labs to compete on the world stage.

Ethical and Social Considerations: The problems must align with principles of responsible AI, ensuring fairness, transparency, and ethical compliance.

Top Priority Applied AI Topics

Here is a curated list for top 20 research topics. Please note that the topics are not presented in any order.

Deepfake Detection & Mitigation

Brief Explanation: Deepfake technology involves sophistically manipulating videos and audio to create fake content, posing significant challenges to information integrity.

What has been done: Techniques such as deep learning models, GANs, and forensic analysis have been used to detect deepfakes, yet performances are far from enterprise grade reliable product.

Proposition: Develop more robust detection algorithms that can adapt to rapidly evolving deepfake technologies and establish regulatory frameworks for content verification.

Multimodal AI Models (including Agent based Models) for Diverse Applications and Content Moderation

Brief Explanation: Multimodal AI models integrate different data types (text, images, audio etc.) to enhance decision-making, but training of the model is non-obvious. Combining multimodal data and agent-based systems can lead to more intelligent and autonomous systems. However, content moderation in multimodal setting is extremely challenging due to problem of proper contextual alignment of different modalities.

What has been done: Transformer-based architectures (like CLIP) and multimodal datasets have been developed to improve model performance across different modalities.

Proposition: Focus on improving the quality & interpretability of these models and reducing biases to ensure fair and accurate content moderation across platforms. Also, develop better frameworks for training and evaluating multimodal agent-based systems, particularly in real-world, dynamic environments.

Automatic Speech Recognition (ASR) for Under-Represented Languages

Brief Explanation: ASR systems are essential for converting spoken language into text but often fail with under-represented languages.

What has been done: Efforts include creating new datasets and adapting existing models to low-resource languages using transfer learning.

Proposition: Invest in collecting diverse linguistic data and developing more inclusive models that can handle the unique characteristics of these languages.

Fake Voice Detection and Voice Privacy (including speech watermarking)

Brief Explanation: The rise of synthetic voices and voice cloning necessitates tools to detect fake voices and protect voice privacy.

What has been done: Algorithms for detecting synthetic voices and embedding watermarks in speech signals have been explored.

Proposition: Enhance the robustness of fake voice detection systems and develop more sophisticated voice watermarking standards (that do not degrade audio quality) & regulatory frameworks.

Trainable activation function (e.g., Kolmogorov Arnold Network (KAN) representation)

Brief Explanation: Trainable activation functions, like Kolmogorov-Arnold Networks (KANs), offer several advantages like better representation, improved interpretability and efficiency in learning

What has been done: Establishing KANs as potential replacement for MLPs

Proposition: Future research in this direction includes developing efficient algorithms for determining the optimal univariate functions and their parameters and combining the strengths of KANs and traditional neural networks (MLPs) to leverage both interpretability and flexibility

Beyond Transformer Architectures including Sub-quadratic Time Sequence Modelling (selective state space model)

Brief Explanation: While Transformers dominate the current AI landscape, there are reported shortcomings (notably, quadratic attention) with the same architecture. Exploring alternatives could lead to more efficient and capable models.

What has been done: Emergence of alternative architectures like sub-quadratic time sequence modelling with selective state space (e.g., mamba).

Proposition: Invest in research on novel architectures that can match or surpass Transformer capabilities in specific tasks, with a focus on efficiency and scalability.

Neural Speech Synthesis from Brain Signals

Brief Explanation: Converting brain signals directly into speech could revolutionize communication for people with speech disabilities.

What has been done: Early-stage research has shown that neural networks can decode brain signals to produce synthesized speech.

Proposition: Improve the accuracy and reliability of these systems through more refined models and better understanding of the neural processes involved

Viewpoint Variation (Computer Vision)

Brief Explanation: Handling different viewpoints in visual data is critical for applications like object recognition and autonomous driving.

What has been done: Techniques like 3D reconstruction and view-invariant feature extraction have been developed.

Proposition: Focus on developing models that can generalize across unseen viewpoints and integrate real-time adaptation capabilities.

Addressing Bias, Interpretability, Intervenability & Algorithmic Fairness in Foundation Models

Brief Explanation: Foundation models like GPT-4 have been criticized for biases and lack of interpretability.

What has been done: Efforts include creating fairness benchmarks and developing interpretability tools.

Proposition: Advance research in creating models that can be audited for bias and are transparent in their decision-making processes, enabling actionable interventions.

Bias in Recommendations

Brief Explanation: Recommender systems often reinforce biases present in the training data, leading to unfair outcomes.

What has been done: Techniques like debiasing algorithms and diversity-promoting strategies have been proposed.

Proposition: Develop more sophisticated methods to identify and mitigate biases in real-time and across various recommendation contexts.

Physics-Driven Generative Models

Brief Explanation: Incorporating physical laws into generative models can improve their accuracy and applicability in scientific domains.

What has been done: Models integrating physical constraints into GANs and neural networks have shown promising results.

Proposition: Extend these models to more complex physical systems and ensure they are interpretable and reliable for scientific predictions.

Informal Language and Cultural Specificity

Brief Explanation: AI models often struggle with informal language and cultural context, leading to misunderstandings and misinterpretations.

What has been done: Efforts include creating datasets that capture informal and culturally specific language use.

Proposition: Focus on enhancing the adaptability of models to diverse linguistic and cultural contexts, including real-time processing of informal language.

Contextual Ambiguity

Brief Explanation: Ambiguity in language can pose significant challenges to AI models, particularly in understanding and generating contextually appropriate responses.

What has been done: Techniques like context-aware models and probabilistic methods have been developed to address ambiguity.

Proposition: Improve models' ability to handle ambiguity through better contextual understanding and integrate user feedback mechanisms for disambiguation.

Enhanced Video Production Tools

Brief Explanation: AI-driven tools are increasingly being used to automate and enhance video production.

What has been done: AI models have been integrated into tools for video editing, color grading, and even scriptwriting.

Proposition: Develop more intuitive and powerful tools that integrate AI seamlessly into the creative process, enabling real-time enhancements and edits.

Generation of Synthetic Data

Brief Explanation: Synthetic data generation is crucial for training models where real-world data is scarce or sensitive.

What has been done: GANs and other generative models have been used to create synthetic datasets for various domains.

Proposition: Focus on improving the realism and diversity of synthetic data, ensuring it captures the complexity of real-world scenarios.

Machine Unlearning and Responsible Data Erasure

Brief Explanation: Machine unlearning involves removing data from models in a way that the model "forgets" it, which is crucial for privacy and regulatory compliance.

What has been done: Initial frameworks for machine unlearning have been proposed, focusing on selective data deletion from models.

Proposition: Develop more efficient and reliable unlearning techniques that can be applied to large-scale models without compromising performance.

Novel AI Architectures without MatMul Operations

Brief Explanation: Traditional AI architectures rely heavily on matrix multiplication (MatMul), which can be computationally expensive.

What has been done: Research is exploring alternative computational paradigms that avoid or minimize MatMul operations.

Proposition: Further research is needed to develop and optimize these architectures, ensuring they are competitive with MatMul-based models in terms of performance and efficiency.

Sarcasm and Irony Detection

Brief Explanation: Detecting sarcasm and irony in text is challenging due to the subtlety and context-dependence of these forms of expression.

What has been done: Models leveraging context and sentiment analysis have shown some success in detecting sarcasm and irony.

Proposition: Develop models that can better understand and interpret sarcasm and irony, perhaps by integrating deeper contextual and pragmatic cues.

Synonyms and Semantic Variability

Brief Explanation: Handling synonyms and semantic variability is crucial for accurate language understanding and generation.

What has been done: Synonym detection and embedding-based approaches have been developed to handle semantic variability.

Proposition: Improve the robustness of models to synonymy and polysemy, ensuring they can maintain consistency and accuracy across different contexts.

CRISPR + LLMs/Graphs for Agriculture and Environmental Management

Brief Explanation: Combining CRISPR gene-editing technology with large language models (LLMs) and /or graph neural network could revolutionize biological systems including agricultural practices and environmental management.

What has been done: Early research has explored the integration of CRISPR with AI for precision agriculture and ecosystem management.

Proposition: Using gene editing technology like CRISPER/cas9 with LLM/ Graphs to optimize the gene sequence for a particular target like nutrient enriched livestock feed or carbon capturing microbes would revolutionize Agriculture and Environmental Management. While this may be promising approach, we also need to address carefully any ethical concern arising from this evolving technology.

Conclusion

The Indian AI ecosystem is at a pivotal moment, with a clear need for deep research to drive innovation in AI and machine learning. Nasscom's initiative to foster a startup/AI Labs ecosystem focused on advanced R&D is key to positioning India as a leader in AI. Through the establishment of an AI research cluster and strategic collaborations with academic institutions like IISc and IITs, Nasscom aims to bridge the gap between research and market-driven needs.

The identification of key applied AI research challenges is only the beginning. Solving these problems requires the collective effort of the entire ecosystem—startups, academia, industry, and policymakers. Nasscom is eager to catalyze this collaboration, ensuring that together, we can propel India to the forefront of global AI innovation.

Annexure

In addition to the top 20 topics, a secondary list of research topics was also compiled. Although not featured in the top priority list, these topics hold significant relevance for the future and warrant further exploration.

Adapting to Changing User Preferences
Advanced MRI Techniques
AI Reasoning Enhancement for Urban Planning
Modelling Background Clutter in Computer Vision Applications
Benchmarking for Code Information Retrieval
Data Quality Framework
Development of Multilingual Datasets
Domain-Specific Language
Earth Observatory & geo-spatial analysis
Educational Content Generation
Efficient Fine-Tuning in LLMs across different architectures (e.g., PEFT, REFT)
Efficient Search Inside Video
Improved Rendering Techniques for Large-Scale Scenes
Mixing Languages (Code-Switching)
Privacy-Preserving Compute Techniques
Spelling and Grammar Variations
Text-to-Speech Systems with Diverse Indian Languages
Variability in Lighting Conditions in Computer Vision Applications
Fine Grain Activity Recognition
LLMs for edge environments & lightweight architecture
Handling Occlusion in Computer Vision Applications
Paediatric Wrist Fracture Detection
XR Related Applications
High-Quality 3D Modelling for Heritage Conservation
AI Agents for Elderly Care
AI for Space Debris Management
AI-Enhanced Quantum Simulation for Material Discovery

Challenges in Autonomous Vehicles

Consumer Product Optimization Through Self-Play Techniques

Smart City Behavioural Framework

Speech Analysis Using LLMs

Unified Framework for Creative Content Generation

Advanced Materials using GenAI

Emotional Variability in Speech

Enhanced ECG Signal Processing

Homonyms

LLM Training for Low-Resource Languages

Multi-camera Re-ID & Tracking

Realistic Portrait Animation Using Raw Video

Real-Time Visual Translation for Accessibility

Urban Scene Understanding

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