# A Unified View of AI Progress Through the Lens of Categorization

Zhongren Wang

Independent Researcher

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## Abstract

From expert systems to large language models, the entire history of artificial intelligence can be understood as three successive paradigm shifts in how machines perform **categorization**. This paper argues that perception, reasoning, and generation — all core abilities of intelligence — are ultimately different manifestations of categorization. The breakthrough of modern generative AI lies in liberating categorization from human-defined constraints through autoregressive, self-referential loops.

## 1. Rule-Based Categorization (1950s–2010)

Early AI systems relied entirely on human-written logical rules. An email filter might classify a message as "spam" if it contained keywords like "prize" and "sex". This symbolic approach was precise but catastrophically brittle.

| Key Techniques | Representative Works / Systems |
|---|---|
| Hand-crafted rules & knowledge bases | Expert systems, early symbolic AI |
| Decision trees & rule induction | ID3, C4.5 |
| Hand-engineered features + shallow learners | SVM, traditional computer vision (SIFT + BoW) |

# 2. Supervised Categorization (2012–2022)

Deep learning allowed machines to learn categories directly from labeled data. Models achieved superhuman accuracy on closed-set tasks, yet remained fundamentally constrained: categories were still rigidly predefined by humans.

| Key Techniques | Representative Works / Models |
| --- | --- |
| Deep convolutional networks & self-supervised pretraining | AlexNet (2012), ResNet, Vision Transformers |
| Large-scale language modeling | RNN, LSTM, BERT, GPT-2, T5 |
| Supervised fine-tuning on labeled datasets | ImageNet classification, GLUE/LM fine-tuning |

# 3. Autoregressive Semantic Categorization (2023–)

The core mechanism of contemporary large language models is autoregressive generation: every generated token becomes input for the next prediction, forming a closed self-referential loop. The model no longer chooses from fixed categories — it dynamically constructs open-world categories in continuous semantic space at every timestep.

## Empirical Evidence with Detailed Explanation (2020–2025)

| Key Phenomenon | Representative Works | Why It Is Still Categorization |
| --- | --- | --- |
| Every generated token is the result of classification over the entire vocabulary | All autoregressive LLMs (GPT series, LLaMA, Claude, Gemini, Qwen, DeepSeek, etc.) | 50k–200k-way classification repeated thousands of times = generation itself |
| In-context learning without parameter updates | GPT-3 (2020) → all post-2022 models | Creates a temporary task-specific category inside the context window |
| Chain-of-Thought, Tree-of-Thought, self-consistency | Wei 2022, Yao 2023, Wang 2023 | Forces step-by-step creation of finer-grained sub-categories |

| | | |
|---|---|---|
| Self-attention mechanism | Transformer (Vaswani et al. 2017) | Real-time clustering of tokens into dynamic relevance categories |
| Emergent abilities from scale | Wei et al. "Emergent Abilities of Large Language Models" 2022 | Scale unlocks richer internal category systems |
| Zero-shot / few-shot generalization | Brown et al. GPT-3 2020, OpenAI 01/03 series 2024–2025 | Instant construction of entirely new categories from prompts |
| Tool use & agent behavior | GPT-4 + tools, AutoGPT, BabyAGI, MetaGPT 2023–2025 | Classification over dynamically generated discrete action spaces |
| Multimodal unified modeling | GPT-4V, Gemini, LLaVA, Qwen-VL, Claude-3 2023–2025 | Unified categorization of vision patches and text tokens |
| Long-context reasoning (100k–1M+ tokens) | Gemini 1.5 (1M), Claude 3 (200k), Qwen-Long 2024–2025 | Maintains thousands of simultaneous dynamic categories without collapse |
| Self-improvement loops (RLAIF, STaR, Reflexion) | Huang 2022, Zelikman 2022 | Re-classifies its own output into higher-quality categories |

# 4. Future Predictions (2026–2035)

**Prediction 1** — Categorization will become fully recursive and self-modifying: models will generate and rewrite their own categorization architectures on the fly ("category compilers").

**Prediction 2** — Explicit, persistent, queryable world models will emerge as multi-level living category hierarchies maintained inside the weights.

> **Prediction 3** — AGI will be reached the moment a system can autonomously generate, critique, and permanently internalize entirely new categories without any human text scaffolding.

> **Prediction 4** — All future architectural breakthroughs (Mamba, liquid networks, test-time training,.) will succeed only insofar as they enable richer, faster, or more efficient dynamic category construction.

## Conclusion: Categorization Is Intelligence

The seventy-year journey of AI in one sentence:

- 1950s → Humans write the categories
- 2012 → Humans label the categories
- 2023 → Humans describe the task; AI invents the categories
- 203? → No human input; AI autonomously evolves its own categories

**Categorization is not something intelligence does — categorization is what intelligence is.**