Abstraction in Language & Communication - Category Theory and Large Language Models

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Introduction

Abstraction in language is crucial for reasoning and problem-solving. This study of research literature explores the use of levels of abstraction to reframe questions and enhance prompting strategies.

Background:Hayakawa's Ladder of Abstraction

The word 'animal' is an abstraction covering all animals; 'cow' is a narrower abstraction; 'Bessie the cow' is a specific, lower-level abstraction. Languages function by integrating these ascending and descending levels of abstraction.
The example below depicts the concept of money, based on Hayakawa's Abstraction Ladder.

Example Term(s)	**Semantic Role**	**Category Theory Analogue**
Penny, Dime, Quarter	Hyponyms	Objects in Category
Coin, Dollar Bill	Higher-level Hyponyms	Morphisms (value conversion)
Currency Units (USD, EUR, INR)	Hypernyms	Functor to Currency Category
Cash, Bank Account, Credit	Generalized Categories	Morphism across 'Money' context
Money	Higher-level Hypernym	Terminal object or abstraction functor

Table: Abstraction ladder for *Money*

Notes

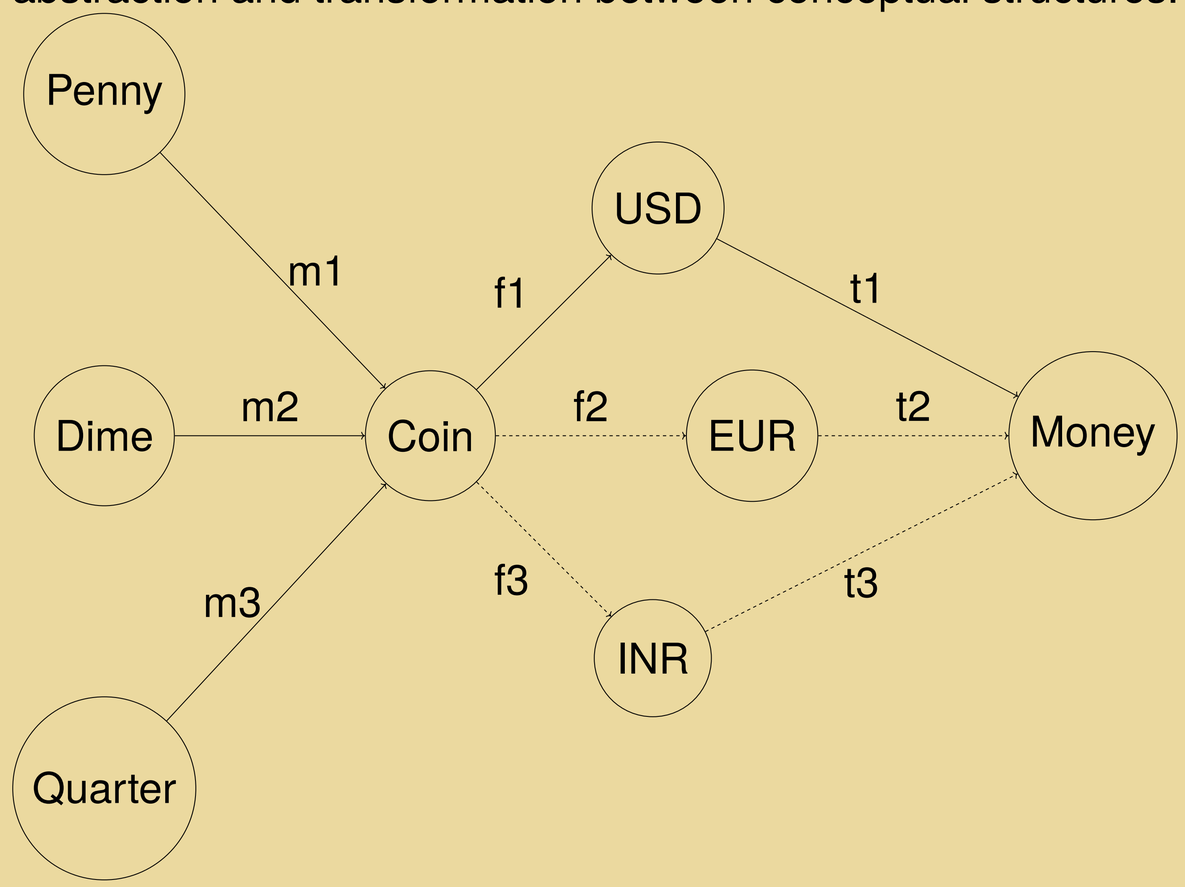
- **Hyponymy** and **Hypernymy** define semantic hierarchies in language.
- **Semantic Generalization** refers to abstracting specific terms to broader categories.
- **In Category Theory:**
  - **Objects** represent specific entities (e.g., Penny, Dollar)
  - **Morphisms** are value-preserving relationships (e.g., Penny → USD)
  - **Functors** map categories (e.g., Coins → Currency → Money)

Relevance to Large Language Models (LLM)

LLMs implicitly operate across abstraction levels. Step Back Prompting is one example of high-level abstraction in use. This study will extend the implementation of multiple sliding levels of abstraction, considering linguistic and categorical theories to improve question reframing.

Category Theory Representation

Category Theory formalizes abstraction through structures such as Objects, Categories, Morphisms, Functors, and Natural Transformations. These structures model relationships and transformations across systems. Category Theory models abstraction and transformation between conceptual structures.



Synthesis and Proposed Method

A mapping between Hayakawa's Ladder and Category Theory structures can allow for prompt reformulation.

- Morphisms → abstraction level changes
- Functors → abstraction alignment across contexts

Goal: Add abstraction operators into LLM prompting.

Benefits to Human-AI (HAI) Interaction

Understanding abstraction improves HAI. Better dialogue, trust, and interpretability can result from shared abstraction frameworks.

References

"To understand the question is very nearly to know the answer." **Dr. Tom Leinster (Basic Category Theory)**