

Motivation

- ✓ CNNs provide outstanding performance in image semantic processing tasks.
- ✓ CNN description models do not codify their representation based on the Cognitive Science foundations to represent the meaning.
- ✓ We bring into view the Prototype Theory as a theoretical framework to represent the semantic meaning of the visual information contained in an image.

Background

Elements of Prototype Theory

- The *prototype* stands for the *central semantic meaning* of the category [1,2].
- *Category internal semantic structure* [1,2]: A category member is positioned closer to the category prototype based on its typicality degree.
- *Object categorization* is obtained based on the similarity of a new exemplar with the learned prototypes [3].
- Main characteristics (*prototypicality effects*) [1-5]:

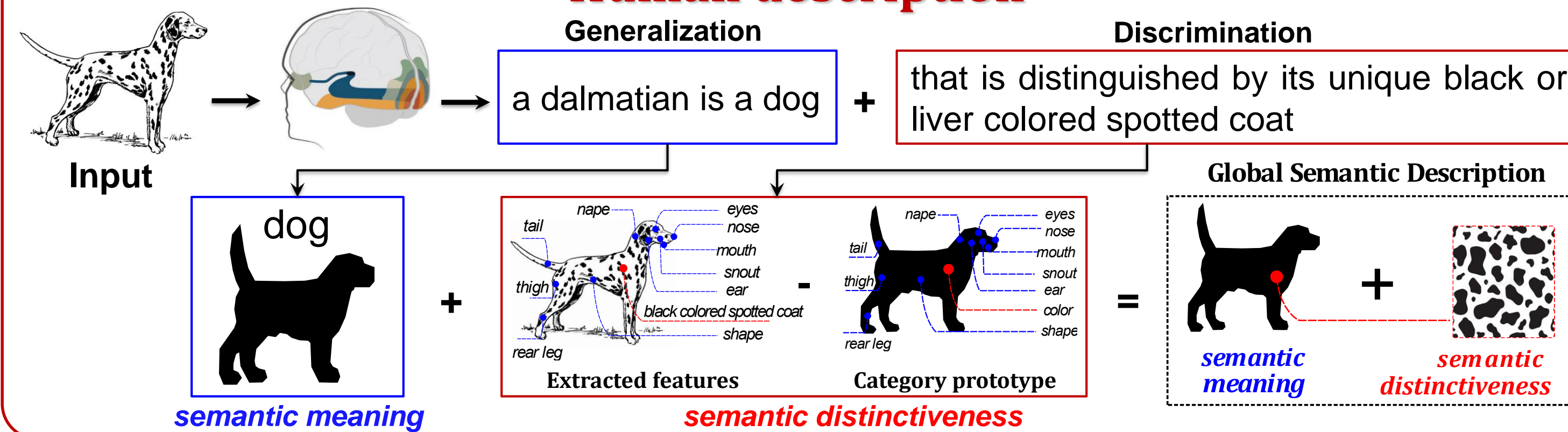
	<i>extensional</i>	<i>intensional</i>
non-equality (salience effect, core/periphery)	Difference of typicality and membership salience	Clustering into family resemblances
non-discreteness (demarcation problems, flexibly)	Fuzziness at the edges, membership uncertainty	Absence of necessary-and-sufficient definitions

Problem Statement

How to include the semantic of a category prototype into the global semantic description of objects?

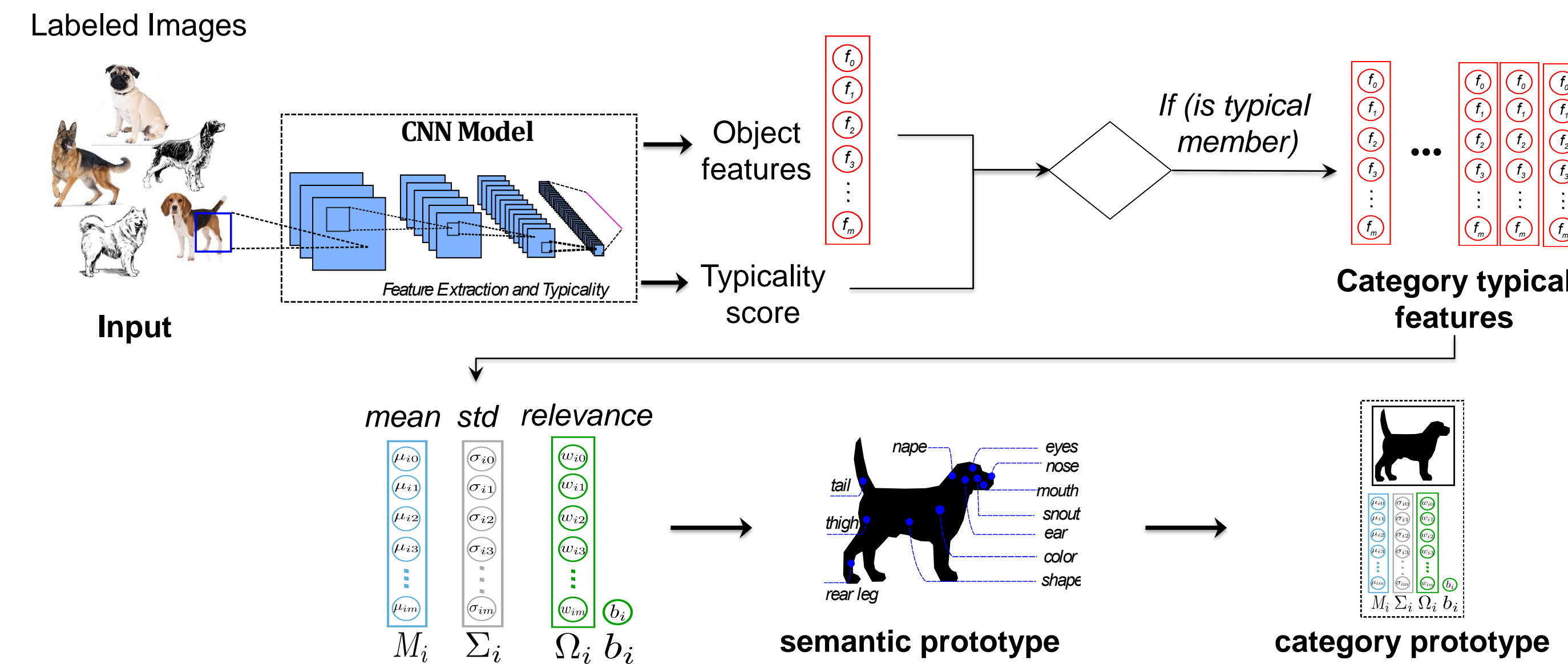
Intuition

Human description

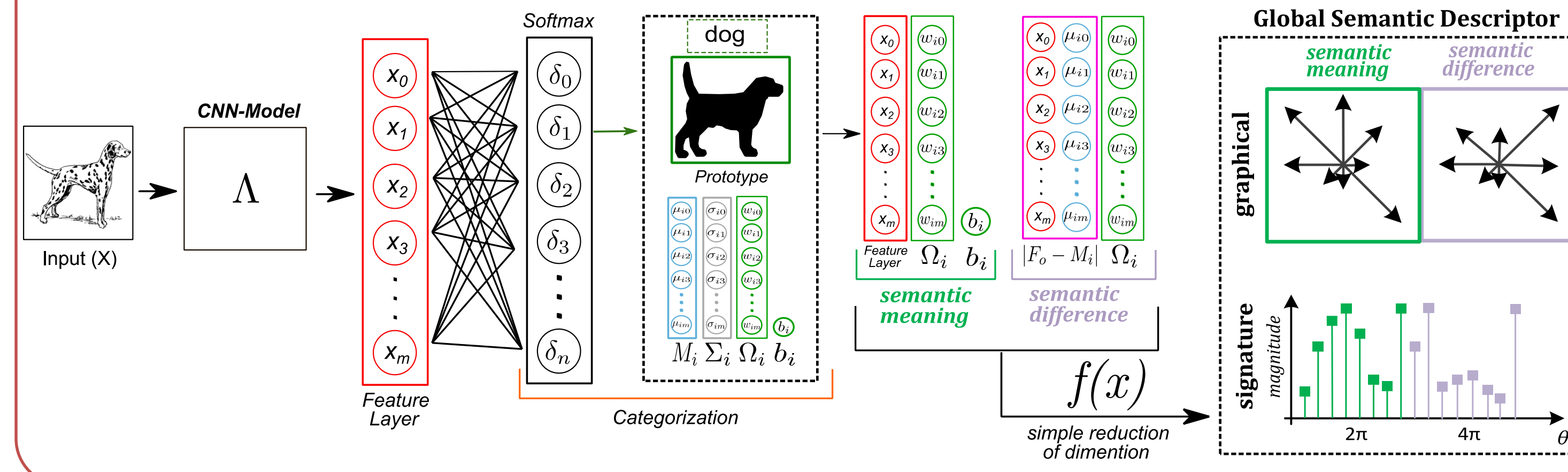


Methodology

Step 1 - Computing prototypes

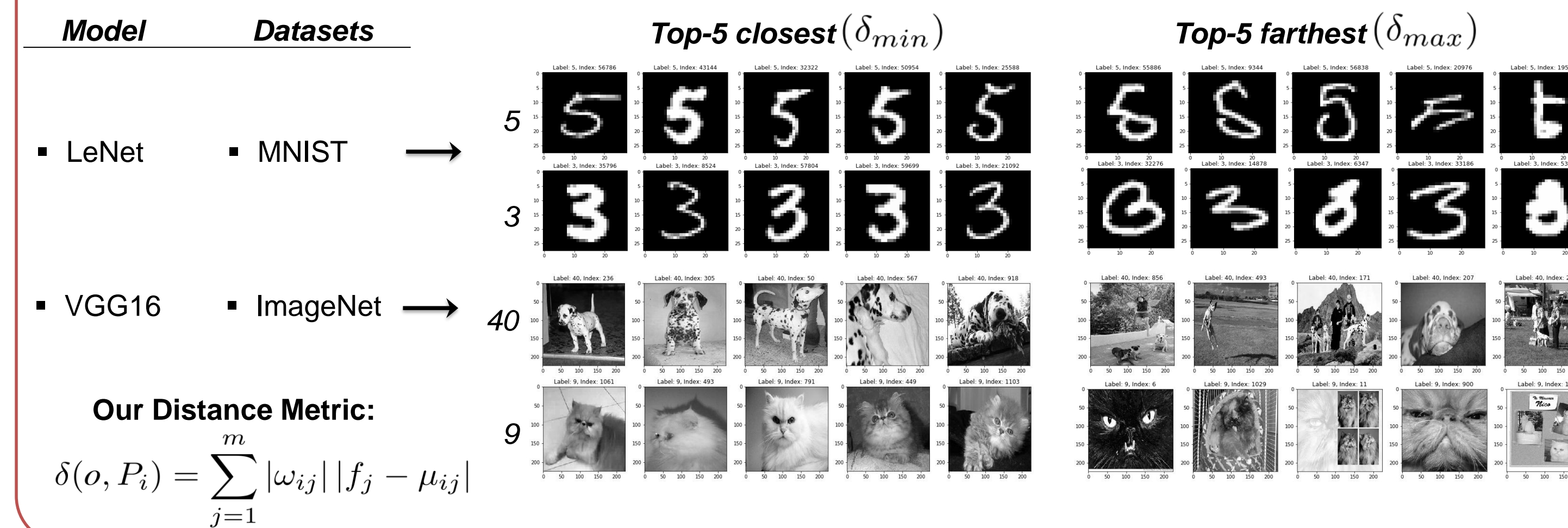


Step 2 - Global Semantic Description (GSDP)



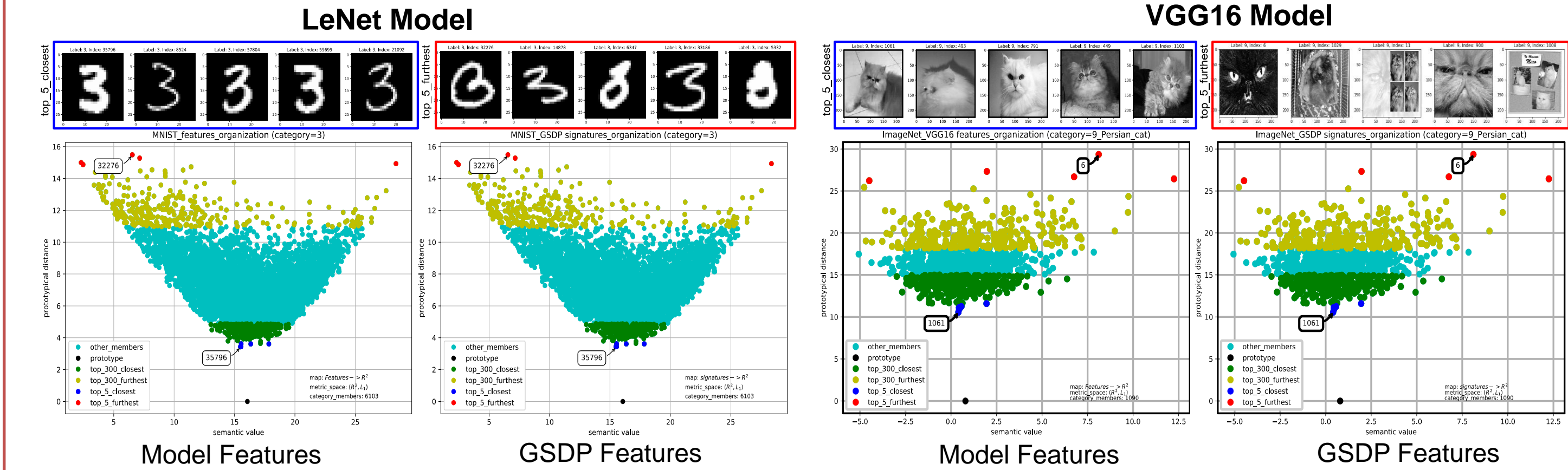
Results

Prototypical behavior of category members



Results

Category internal structure



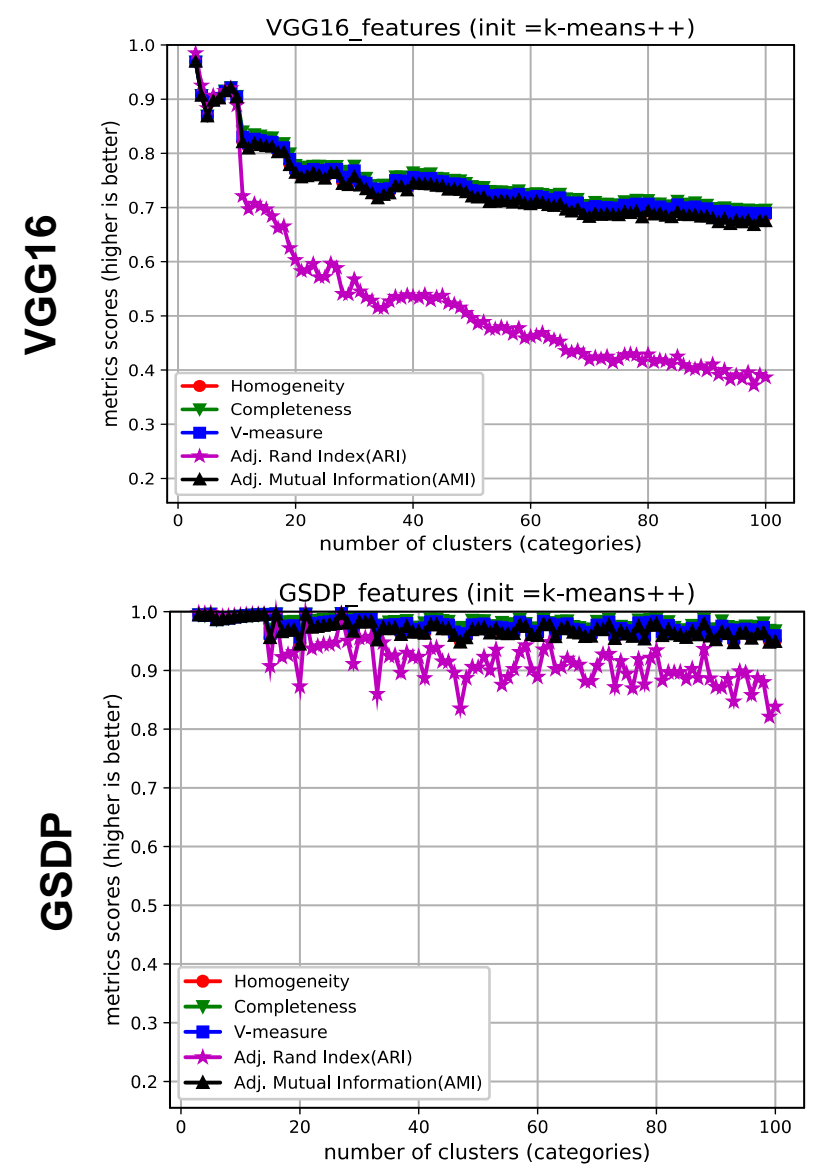
Performance Evaluation

Cluster Metrics Scores [6]

Descriptor	Size	Time (ms)	Metrics Scores				
			H	C	V	ARI	AMI
GIST	960	1210	0.05	0.05	0.05	0.01	0.05
LBP	512	1380	0.02	0.03	0.03	0.01	0.02
HOG	1960	25	0.04	0.04	0.04	0.01	0.03
Color64	64	125	0.12	0.12	0.12	0.04	0.11
Color_Hist	512	38	0.08	0.08	0.08	0.03	0.07
Hu_H_CH	532	145	0.04	0.04	0.04	0.01	0.02
VGG16	4096	62	0.77	0.78	0.77	0.60	0.76
VGG16_PCA_25	25	80	0.76	0.77	0.76	0.60	0.75
VGG16_PCA_256	256	80	0.76	0.77	0.77	0.59	0.76
GSDP (Our)	256	120	0.94	0.97	0.95	0.87	0.94

- Our descriptor encoding significantly outperforms other image global encodings in terms of cluster metrics.

Cluster Metrics History



Conclusion

Our *prototype-based description model* proposes a starting point to introduce the theoretical foundation related to the *representation of semantic meaning* and the *learning of visual concepts* of the Prototype Theory in the CNN-Descriptors family.

1. E. Rosch. Cognitive representations of semantic categories. Journal of Experimental Psychology, 1975.
2. E. Rosch and C. B. Mervis. Family resemblances: Studies in the internal structure of categories. Cognitive psychology, 1975.
3. Rosch, Eleanor. Principles of categorization. Cognition and categorization, 1978.
4. D. Geeraerts. Diachronic prototype semantics: A contribution to historical lexicology, 1997.
5. D. Geeraerts. Theories of lexical semantics. Oxford University Press, 2010.
6. J. Yang, D. Parikh, and D. Batra. Joint unsupervised learning of deep representations and image clusters. CVPR, 2016.

