ICML International Conference On Machine Learning

SHANXI UNIVERSITY

Human Cognition-Inspired Hierarchical Fuzzy Learning Machine

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Outline

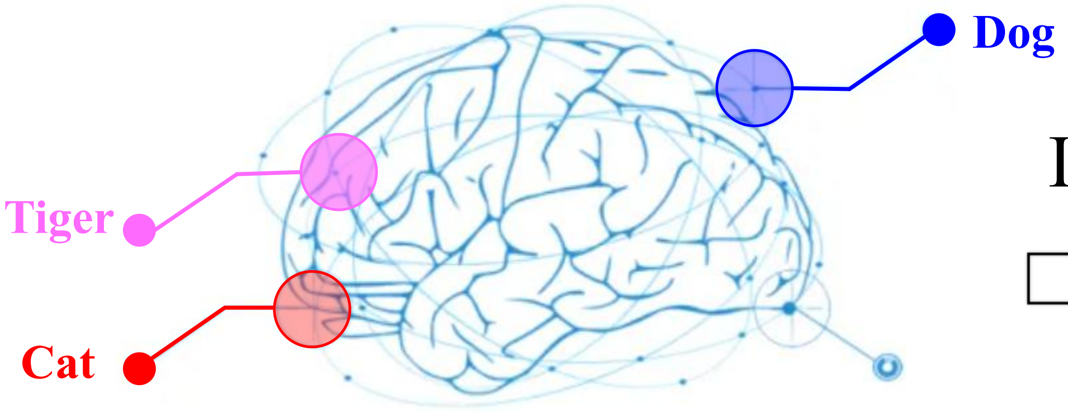
2. Method Design

- **Classification is a cornerstone of machine learning**
- **A vast array of classifiers, categorized into**
  - **Based on discrete 0-1,** such as KNN， Decision tree, Naive Bayes, etc.
  - **Based on continuous proxies of 0-1 loss,** such as Support Vector Machine (hinge loss), AdaBoost (exponential loss), Deep Neural Network (cross-entropy loss), etc.
- **Underlying assumption, i.e., the concepts can be precisely defined**

- **However, in human cognition**
  - **concepts are often inherently ambiguous**
  - **concepts are deeply embedded in human knowledge system**

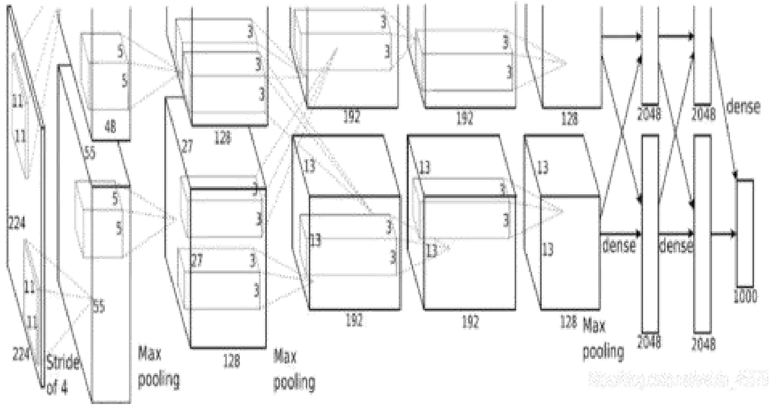
2. Method Design

Overall Goal



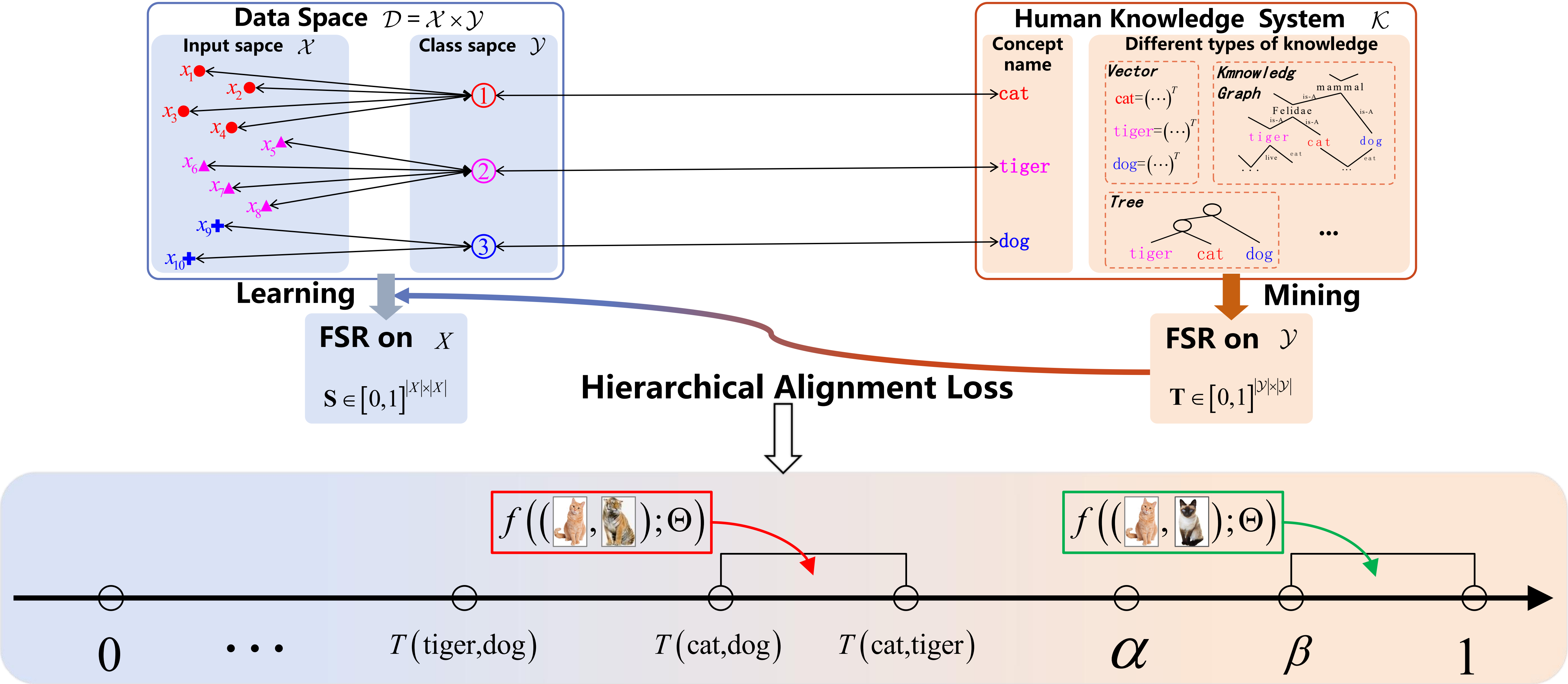
Class Knowledge Contained in Human Knowledge System

Integrate into

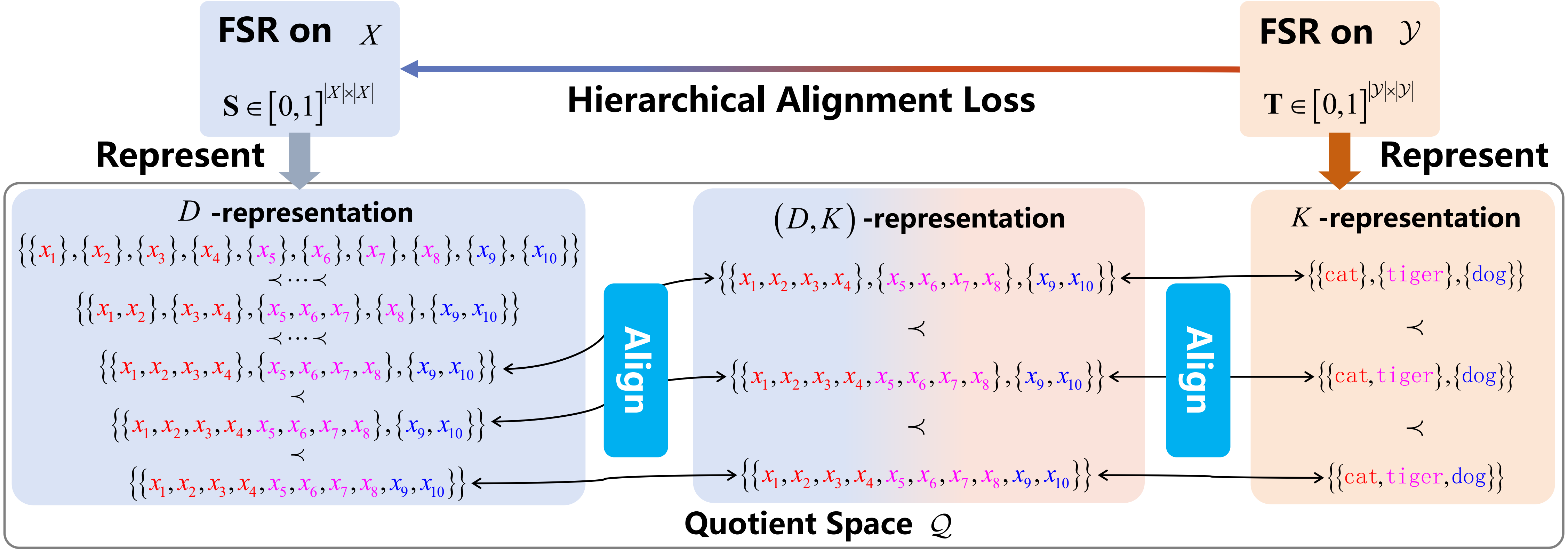


Machine Learning Model

2. Method Design



3. Theory Analysis



① **Construct FSR-based Quotient Space Theory**

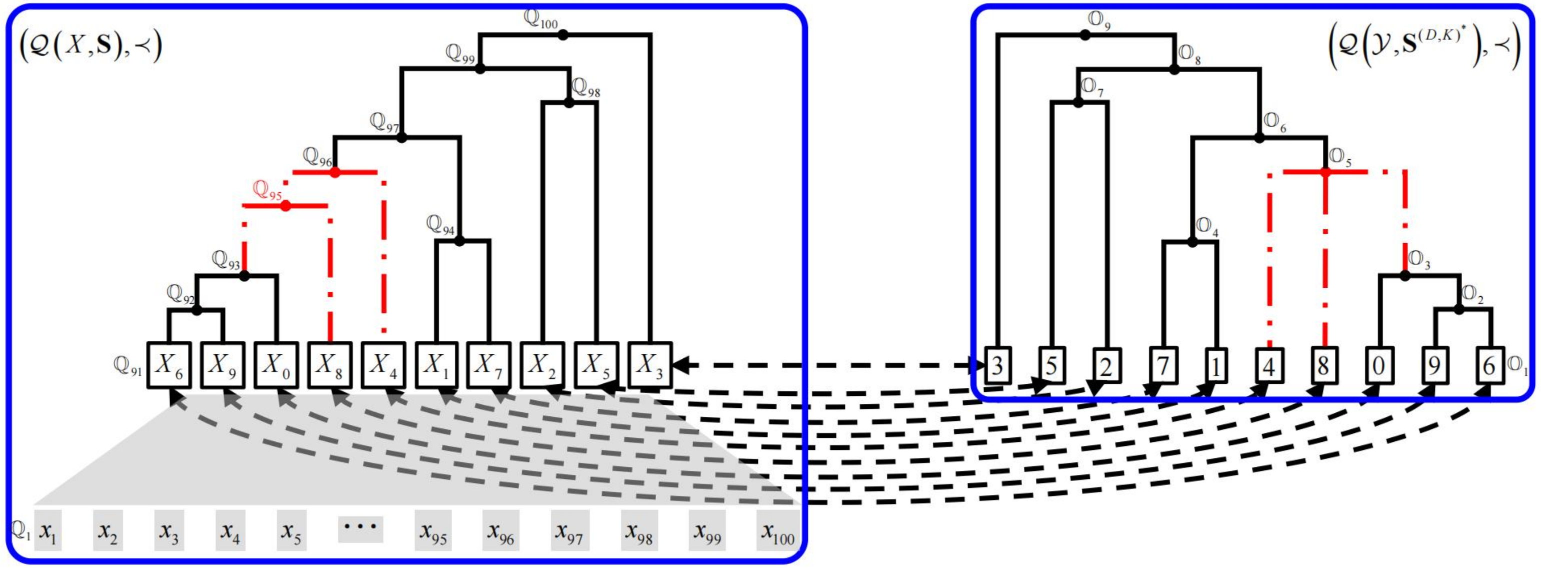
② **Represent Data and Knowledge in Quotient Space**

③ **Align Data and Knowledge in Quotient Space**

4. Experiment

■ Interpretability Analysis

- ➢ MNIST data set, 100 training sample, 10 samples per class
- ➢ Class FSR, constructed by 10 human volunteers
- ➢ Result



The hierarchical structures derived by Human Knowledge and Training Data are aligned

4. Experiment

Generalization Analysis

- **6 data set,** i.e., APY, ImageNet, AWA1, AWA2, FLO, CUB
- **2 types of knowledge,** i.e., class description vector (CK_1) and WordNet (CK_2)
- **Result**

	APY	IMAGENET1K	AWA1	AWA2	FLO	CUB
KNN	85.35	75.49	86.61	89.83	83.39	47.30
DT	63.13	−−	63.47	70.09	42.65	21.64
SVM	84.54	−−	84.26	89.06	86.56	43.89
NB	76.13	73.66	84.67	87.68	85.53	60.27
CEC	89.08	75.62	88.48	91.67	93.58	61.49
FLM	89.42	76.02	89.95	92.79	<u>94.05</u>	<u>66.19</u>
CK_1-HFLM	**90.23**	<u>76.16</u>	**91.10**	**93.59**	**95.06**	**68.78**
CK_2-HFLM	<u>90.21</u>	**76.20**	<u>90.87</u>	<u>93.35</u>	N/A	N/A

Significant gains in Generalization Performance

5. Conclusion and Outlook

- Human knowledge are represented as class FSR
- By hierarchical hlignment loss, class FSR guide the learning process
- Human knowledge and trainig data are aligned on quotient space
- Significant gains in interpretability and generalization performance
- Great promise for open-world learning tasks, such as zero-shot learning and continual learning, etc.

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