2020-1 UROP
2020.03.12

2016-12146 Seri Lee

Goal

Multi-Behavior Recommendation

“Given user behavior data of multiple types, predict users’ next behaviors of target type.”

Approach

- Implement an RNN-based recommendation algorithm for a single behavior type.

- Extend the algorithm to further utilize other types of behaviors by using attention mechanisms.

Previous work (1)

Learning recommender systems from multi-behavior data

Limitations

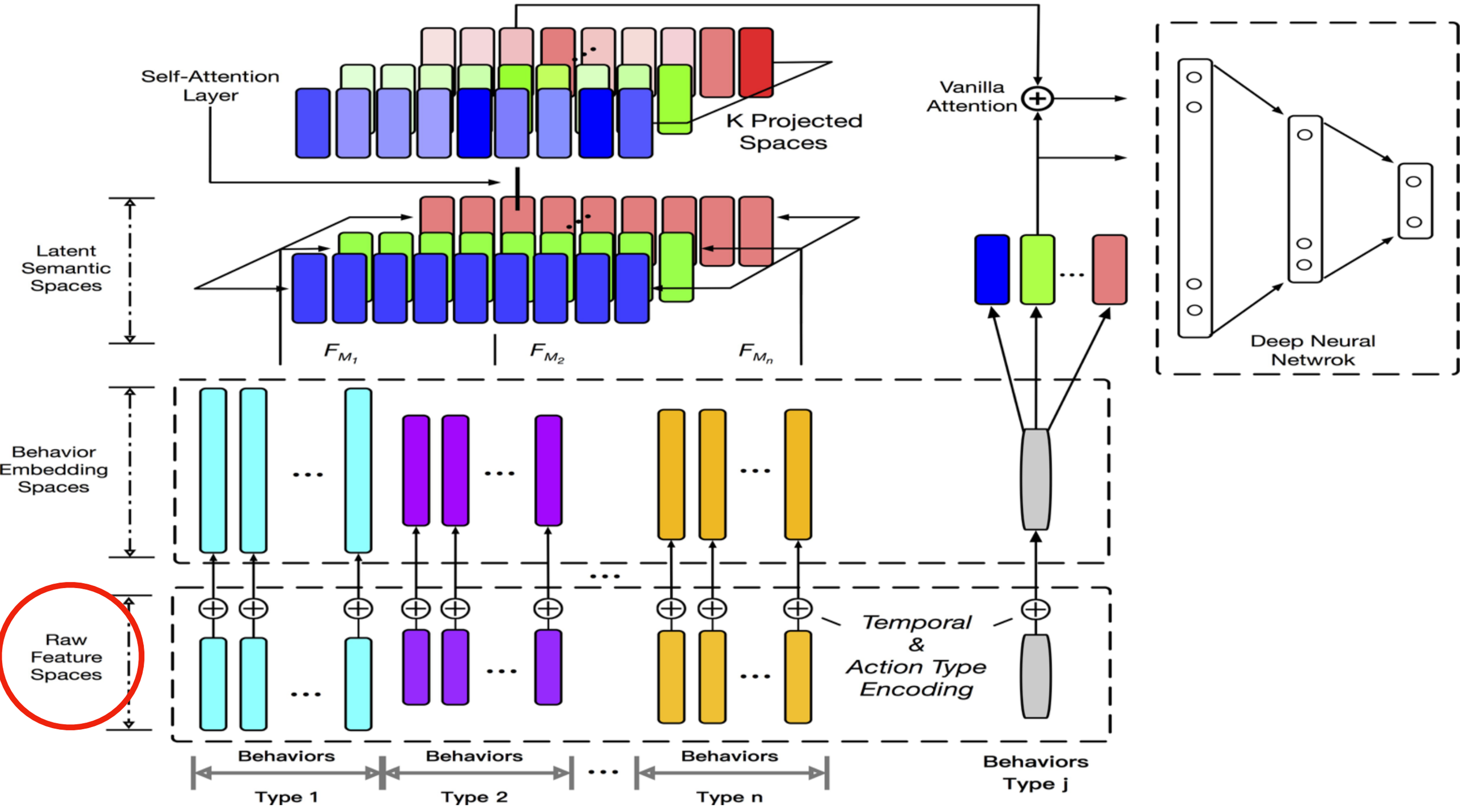
- NMTR cannot capture sequential patterns since it does not consider the time sequence of behaviors.

- New algorithm should capture sequential patterns by using Recurrent Neural Network.

Previous work (2)

ATRank: An Attention-Based User Behavior Modeling Framework for Recommendation

Attention-Based Heterogeneous Behaviors Modeling Framework



Raw Feature Spaces

object

behavior timestamp

$$U = \left\{ (a_j, o_j, t_j) \,|\, j = 1,2,\ldots, m \right\}$$

behavior groups according to target object types

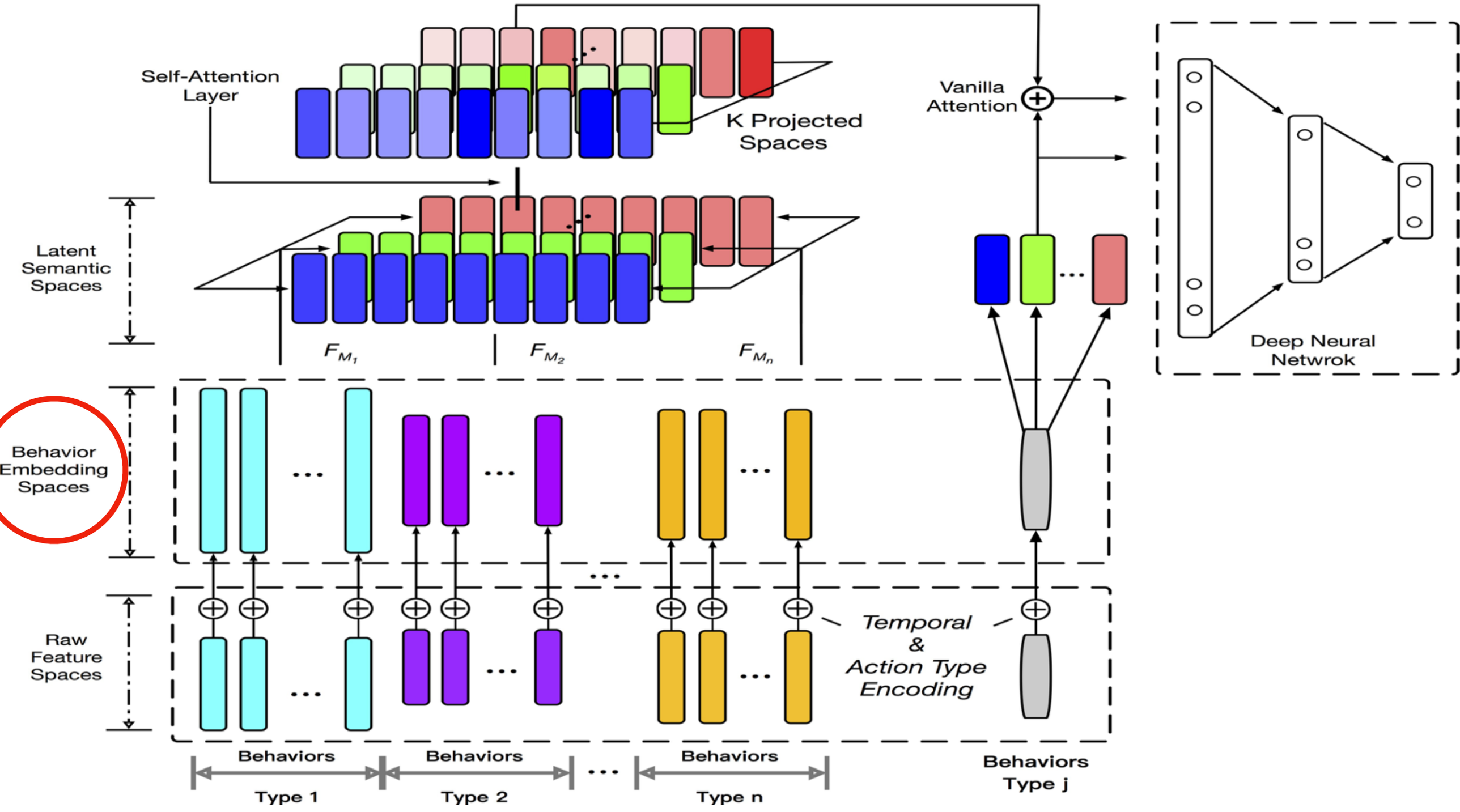
$$G = \left\{ bg_1, bg_2, \ldots, bg_n \right\}$$

$$bg_i \cap bg_j = \emptyset$$

$$U = \cup_{i=1}^{n} bg_i$$

group-specific neural nets to build up behavior embedding

Attention-Based Heterogeneous Behaviors Modeling Framework



Behavior Embedding Spaces

embedding building block

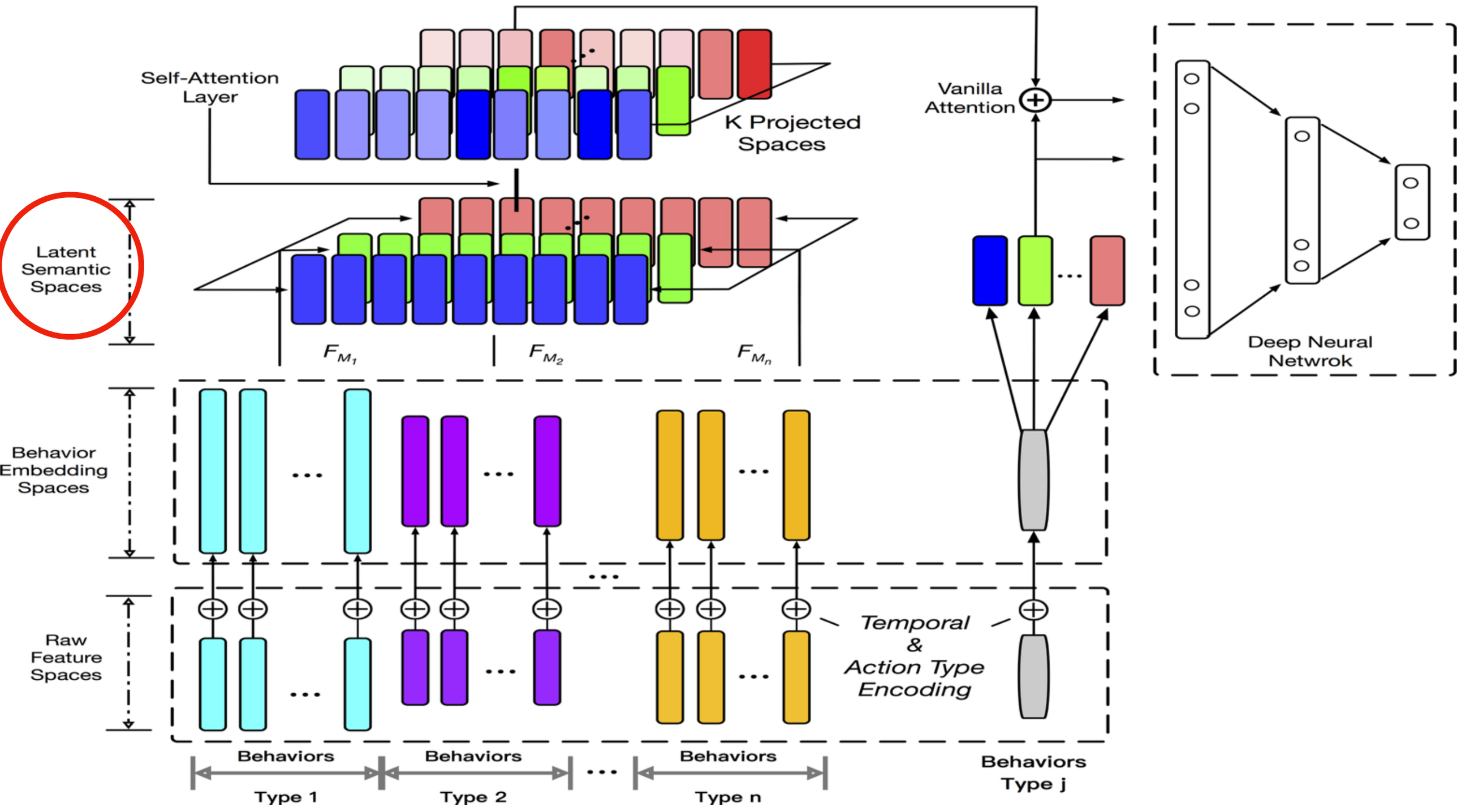
$$u_{ij} = f_i(a_j, o_j, t_j)$$

$$u_{ij} = emb_i(o_j) + lookup_i^t(bucketize_i(t_j)) + lookup_i^a(a_j)$$

output: list of vectors in all behavior groups

$$B = \{u_{bg_1}, u_{bg_2}, \ldots, u_{bg_n}\}$$

Attention-Based Heterogeneous Behaviors Modeling Framework



Latent Semantic Spaces

to fix-length encoding vectors

projection function
(put them into same semantic space)

$$S = concat^{(0)}(F_{M_1}(u_{bg_1}), F_{M_2}(u_{bg_2}), \ldots, F_{M_n}(u_{bg_n}))$$

overall space of dimension size

$$S_{all}$$

projected behavior embedding in each spaces

$$S_k = F_{P_k}(S)$$

projection function
(single layer perceptron, ReLu activation function)

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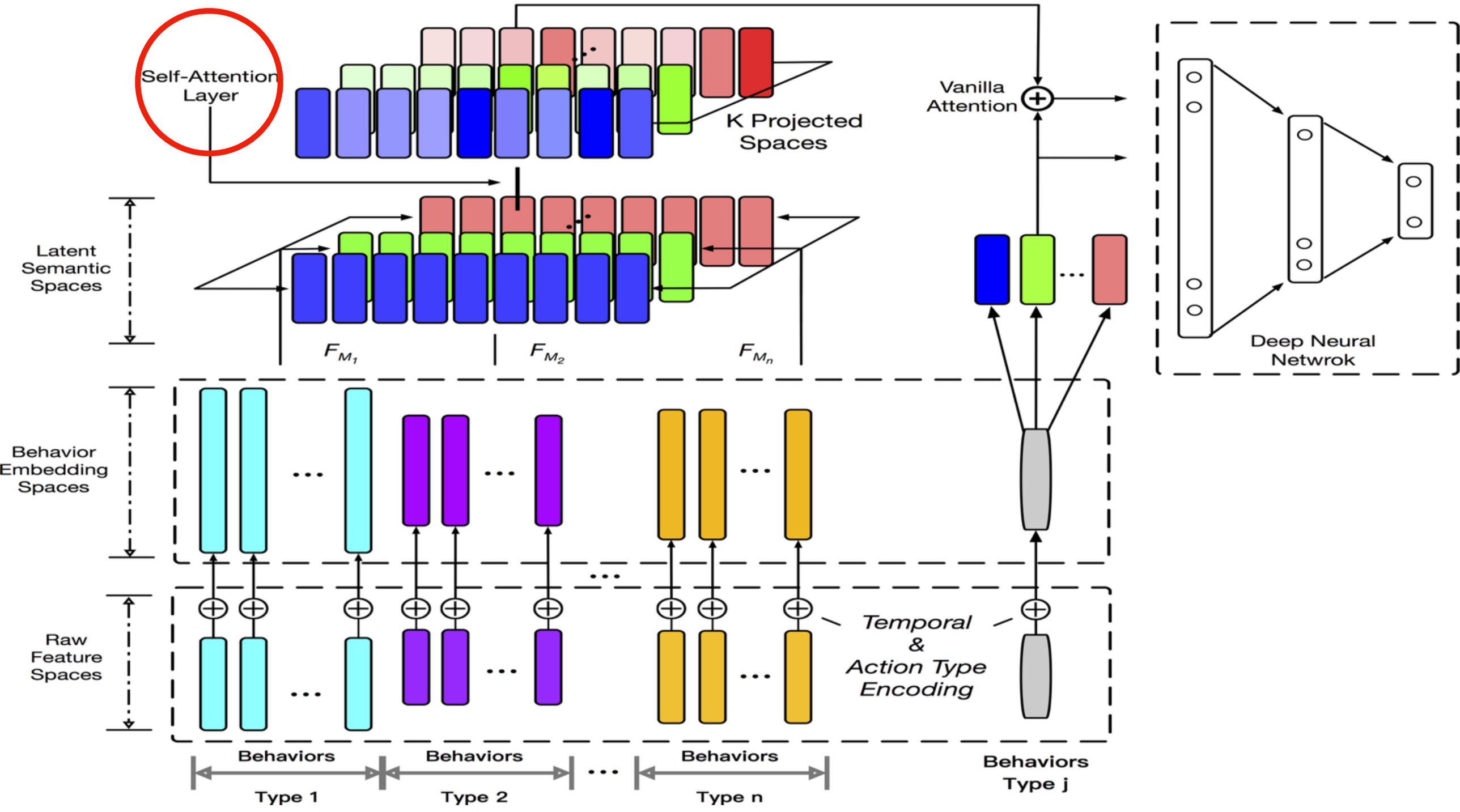


Self-Attention Layer

goal: capture the inner-relationships among each semantic space

self-attention

score vector

$$A_k = softmax(a(S_k, S; \theta))$$

score function

$$a(S_k, S; \theta_k) = S_k W_k S^T$$

<bilinear scoring function>

attention vectors of space k

$$C_k = A_k F_{Q_k}(S)$$

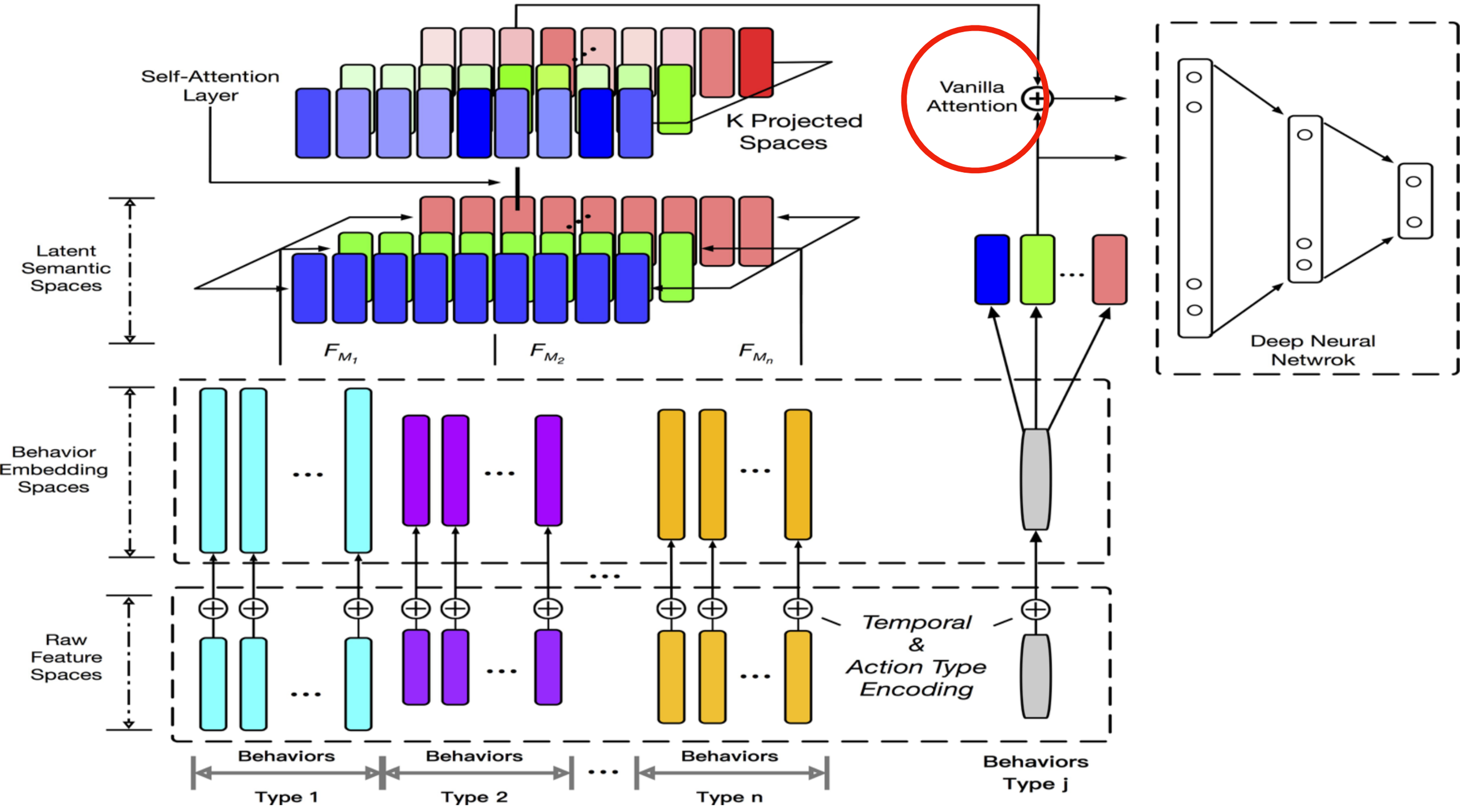
projection function: single layer perceptron+ReLU

concatenated & reorganized

$$C = \mathfrak{F}_{self}(concat^{(1)}(C_1, C_2, \ldots, C_K))$$

feedforward network with one hidden layer

Attention-Based Heterogeneous Behaviors Modeling Framework



Downstream Application Network

: point-wise / pair-wise fully connected nn

vanilla attention

$$\overrightarrow{h_t} = F_{M_{g(t)}}(\overrightarrow{q_t}) \qquad \overrightarrow{s_k} = F_{P_k}(\overrightarrow{h_t})$$

$$\overrightarrow{c_k} = softmax(a(\overrightarrow{s_k}, C; \theta_k))F_{Q_k}(C)$$

final context vector

$$\overrightarrow{e_u^t} = F_{vanilla}(concat_{(1)}((\overrightarrow{c_1}, \overrightarrow{c_2}, \ldots, \overrightarrow{c_K})))$$

final loss function: sigmoid cross entropy loss

$$-\sum_{t,u} y_t log(\sigma(f(h_t, e_u^t))) + (1 - y_t)log(1 - \sigma(f(h_t, e_u^t)))$$

ranking function

Future Work

- Implement ATRank with the given Dataset.

Dataset

- https://www.kaggle.com/mkechinov/ecommerce-behavior-data-from-multi-category-store/data#
- eCommerce behavior data from multi category store
- behavior: view, cart, remove_from_cart, purchase
- object behavior: purchase