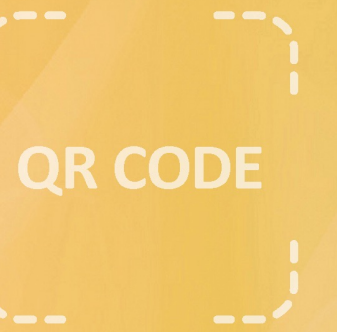


# Knowledge Representation and Reasoning through Neural Network

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## QUESTION

Is there any other way such that we do knowledge representation in neural network which takes continuous input from environment such as vision, audio or any other input?

## ABSTRACT

In this paper, new approach for non-symbolic knowledge representation in deep learning is shown. It mostly consists of theoretical part and arguments answering why it should work. This research paper starts by introducing new theory for new approach of non-symbolic knowledge representation in deep learning and how can it be used for reasoning. It tries to give answer that how can a system which can take continuously input from environment can represent knowledge about environment. Also some inspirations from biological neurons are taken.

## GOAL

Suppose, There's a system or hardware which takes vision or audio input from environment. In this case we want to find way so that this system can learn about its environment and represent knowledge and from that knowledge it should be able to reason. What should be the flow of information and architecture of network in this case?

## NEW THEORETICAL MODEL

Here new theory is proposed, which consists of three main elements:-

- Objects
- Actions
- Elements

### OBJECTS:-

In order to represent knowledge about environment this network must be able to represent different parts of environment. For an example in vision we can think of all the object as parts of environment or in audio different sounds of environment such as sound of car's horn can be thought of as part of environment.

We want to represent those elements. In biological brain whenever such parts are seen in environment, particular group of neurons representing those parts or object gets activated. So in our system there should be also group of neurons which will only have high activation value when object represented by those neurons gets visible in environment. Let's call such groups of neurons as "Object" and represent them with

notation  $\Theta_x$ . Where "x" means this neurons represent object x. Also this group of neurons together makes a vector of "n" dimensions, where n is number of neurons representing object x. This vector can be thought of as latent vector of Object x, which should have following property:

- Average activation value of neurons of this vector should higher when object x gets visible in environment.
- Latent vector should only encode information object x, not about its surrounding.
- If same object is in environment and is changing position or other attributes with time, change in this latent vector should be gradual.

We will get this vectors with VAE kind of architecture.

## FURTHER MORE

### ACTIONS:-

Just by representing objects of environment, we can't represent everything of environment, For example just by knowing that dog is in environment we can't tell what that dog is doing. In order to represent full knowledge of environment we need more. Our objects are not static, they are evolving with time, some are moving, some are changing size or shape, in case of audio some are getting more loud or noisy. We want to extract this information. We can extract it from change of latent vectors of objects. In order to calculate this we can again have similar insight as we had previously. There must be a group of neuron which will only get activated upon seeing particular change in objects latent vector and this neurons will be representation of information about how objects are evolving with time. Let's call this group of neurons

as "Action" which are denoted by  $\Lambda_y$ . Where y means "action y" is happening. We can have VAE kind of architecture to again extract information. Property of this latent vector should be similar to previous one.

### RELATIONSHIP BETWEEN OBJECTS AND ACTIONS:-

But exactly how these two are related?

Probability of object x doing action y must be a function of change of object's latent vector with respect to time, but also it should be a function of object's latent vector because it's latent space same change at another point could mean different thing. So we can have following equation.

$$P(\Theta_x \rightarrow \Lambda_y) = f\left(\frac{d\Theta_x}{dt}, \Theta_x\right)$$

and since this function again would be neural network.

### EVENTS:-

At a particular moment of time, there can be many objects in environment and they might be doing different actions, to represent all things we have to encode them. Here this encoded information is referred as Events. We denote them by  $\mathcal{E}_t$ . Where t denotes timestep t.

All of these three play important role in representing knowledge in our network.

## CONNECTION BETWEEN FIRST-ORDER LOGIC AND THIS THEORY

In the past, Symbolic knowledge representation was used in AI and ML application using first-order logic or predicate logic.

We can draw connection between first-order logic and this theory. Objects of first this theory are similar to constants of first-order logic and if we extend this idea more than average value of  $\Theta_x$  is kind of fuzzy value of that constant. In same way Events are predicates of first-order logic and average value of  $\mathcal{E}_t$  is fuzzy value of that event being true.

That's not the only thing we can create predicate which contains another predicate to create more complex predicate in our network simply by treating these event as

## FURTHER MORE

Objects again. We can create recurrence between objects and events to create more complex and concise knowledge about environment.

## POSSIBLE TRAINING PROCESS

We know that if network is observing data from environment than average value of  $\mathcal{E}_t$  should be high, end if it is low than it means network thinks such event is not possible. This is the really important detail, we can use this fact to train model. We can have approach similar to GANs. We can create another network which gives our main network a data which is not possible to see in real world and if average value of  $\mathcal{E}_t$  is high than we can penalize our model and if model is taking data from real world and average value of  $\mathcal{E}_t$  is low than we can again penalize our model.

## CHALLENGES AND POSSIBLE SOLUTIONS

- There can be many objects and actions, so many subnetwork, we have to find more efficient way for that, however new kind neural networks, known as liquid neural networks, are really good for learning things with very low number of parameters we can use them.
- We will have many objects but haven't define how they might be related to each other. We can associate extra embedding vectors with each objects which will be similar to vector database in NLP.
- In traditional GAN's we have generative model which tries learn distribution of real images from noisy distribution, however here we have to generate sensory data which seems real.

## REASONING IN THIS NETWORK

We can all agree in order to human level reasoning one must be able to do very basic reasoning which is predicting environment itself, which is answering to question that what will happen next if something is happening in environment. In our model it is equivalent to answering what will be  $\mathcal{E}_{t+1}$  given  $\mathcal{E}_t$ . Maybe we also need information of events of previous timestep, in that case we have to introduce something like transformer model in our network to perform better reasoning.

## FUTURE PLAN

- In future, I will start from start again. Trying make network which can extract information related to one object.
- Also I will work on using that latent vectors to find latent vector of action and in the end finding latent vector for event.
- Also I will work on finding relations between objects and actions which is important for knowledge of environment.
- As well we still have to make model to generate data which we will feed to main network to train it.
- Also there should be part in network which solely focus on finding new facts from existing knowledge which is reasoning.