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Message Passing-Based Prediction of Unlabelled Node Embedding Using Graph Neural Network

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Abstract:- Graph neural network are a part of deep learning methods created to perform presumption on data described by graphs. Graph neural network is a neutral network that can straight away be applied to graphs. It provides a agreeable way for node level, edge level and graph level prediction tasks. Moreover, most GNN models do not account for long distance relationships in graphs and instead simply aggregate data from short distances (e.g., 1-hop neighbours) in each round. In this paper work, we carry out node classification using graphs which can be put into large graphs comprise of labelled and unlabelled nodes. Here we can predict the node embeddings of the unlabelled node by using an approach called message passing. For executingthis, we took Cora dataset, provided a overview of it, builded our graph neural network, splitted the data to test and train data, trained it and finally visualised the output.

I. INTRODUCTION

Node classification is applied to large graphs include la- belled and unlabelled nodes.So the assignment is to predict the node embeddings for the unlabelled node based on the neighbouring nodes details and the link between them [1].

Graph Neural Network can carry out node classification, link prediction, graph classification Implementation of node classification are Citation networks/citation graph is a directed graph that represent the citations reddit posts-internet community where people can post contents on numerous topics like politics,cooking etc. youtube videos etc. Link edge-level prediction - approximate the probability of links among nodes in a graph. Graph-level prediction - predicts single value for the entire graph.

Problems faced in node classification is predicting the node embeddings i.e the task here is to determine the unlabelled nodes by involving the labels of their neighbours. Generally, problems of this type are trained in a semi-supervised way (for this we import planetoid which is a graph constructed semisupervised learning method, by incorporating labelled and unlabelled data through the training)with only a part of the graph being labeled.

- *An Approach Used For Node Classification Are:* The node embedding gives us the
- The data about the unlabelled node
- The data about the neighbouring node
- And the citation between them.

By this directive we can predict the unlabelled nodes. So in order to get the node embeddings, we pass the node information through the message passage technique is used. Node classification is one of the techniques in graph neural network.

Graph Neural Networks (GNNs) are a class of deep learning

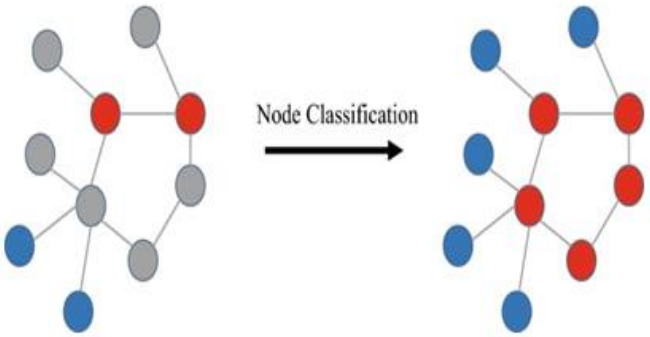

Fig 1 Node Classification

Methods generated to execute inference on data demonstrated by graphs. Graph Neural Network is a neural network that can straight away can be put in to graphs [2]. It come up witha satisfactory way for node level, edge level, and graph level prediction tasks. Graph consisting of nodes, edges and neural network having distinct layers like input layer , hidden layer, and output layer together how to feed the graph to neural network is the GNN, which is shown in Fig 2 and the area which deals with the study of interaction of graph and neural network is called geometric deep learning. The intuition of GNN their neighbors and connections are described naturally.

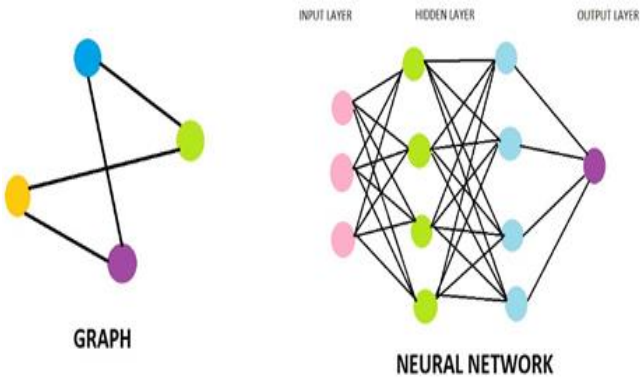

Fig 2 Graph Neural Network

To understand this consider an example that if we remove the connections and neighbors throughout the node, then the node will drop all its information. Therefore, the neighbors of a node and connections to neighbors explain the concept of the node.

- *There are two types of GNNs that are mostly dominant: Graph Convolutional Network (GCN) and Graph Auto-Encoder Network. Let us understand the two below:*

- *Graph Convolutional Network:*

(GCNs)[3] refer to the procedure of applying a spatially moving filter on the nodes of a graph that incorperate embeddings or data relevant to each node to get a characteristic representation of each node. To incorperate input from wider neighborhoods, various convolutional layers, related to a standard CNN, can be stacked. GNN used in node classification as GCN (Graph Convulation Network)layer is the layer which carry out this message passing. We use 2 message passing layers in cora dataset To analyse node embeddings we use message passing layers. GCNs execute similar operations where the model grasps the features by inspecting neighboring nodes.

- *Graph Auto-Encoder Network:*

Auto-encoders are neural networks that integrate two networks:[3] an encoder that downsamples the input by transferring it through convolutional filters to provide a compact characteristic representation of the image, and a decoder that takes the encoder's interpretation as input and tries to reconstruct the input based on it. Graph auto-encoders attempt to comprehend a visual illustration of the graph and then re-construct the graph using the decoder. They may be used to learn graph embeddings and hence anticipate embeddings for unseen nodes and categorize newer nodes into existing categories inside the network.

- *Dataset In Node Classification:*

The Cora Dataset [6] consists of 2708 scientific publications. The dictionary consists of 1433 unique words, Fig 3 is the cora dataset representing 7 labels Nodes are the Publications which are papers, Books, etc. Edges are the citations. Node Features are the word vectors.7 Labels in this dataset are publication type e.g. Neural Networks, Rule Learning, Reinforcement Learning, Probabilistic Methods.

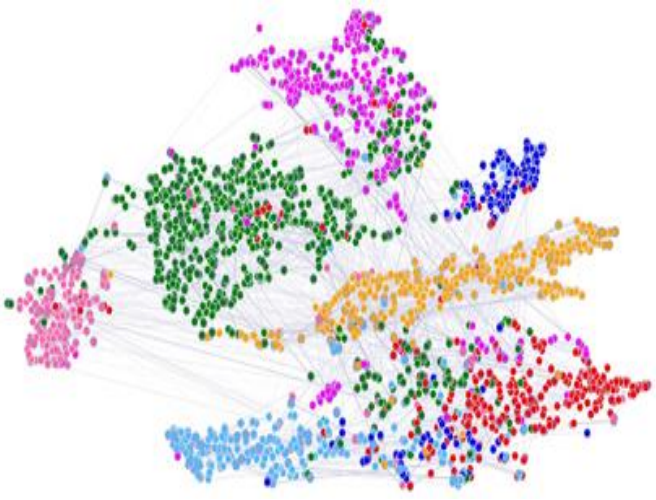
Fig 3 Cora Data Set

The outcome of the work is that for each of the node, we will obtain a prediction. We will use the class with highest probability and this will be our predicted class.

In the upcoming chapters we can get familiarised with related work of the node classification and gist of the related papers, system architecture of our model finally the experimental details including results.

II. RELATED WORK

In this chapter, we look upon machine learning, types of machine learning, graph neural network, applications of graph neural network, node classification and related papers.

A. Machine learning:

Machine learning is one of the part of artificial Intelligence which can detect an output by combining data with statistical tools.[8] A machine learns from the previous data to give extact results. Machine learning is closely belongs to data mining and Bayesian predictive modeling. The machine will receive data as input and it will use an algorithm to formulate answers. A typical machine learning tasks are to give a recommendation. For those who have a Netflix account, all suggestions of movies or series are based on the user's historical data. Technical companies are using unsupervised learning to improve the user experience with personalizing recommendation.

Simulated intelligence is the frontal cortex where all the learning steps occurs. The way the machine learns is fun- damentally as old as individual. Individuals gain from their experience. The more we know, the more viably we can an- ticipate. By this assumption, when we face any dark situation, the likelihood of accomplishment is lower than the known situation. Machines are also pre-arranged something almost identical. To make an exact assumption, the machine sees a model. Right when we give the machine a comparable model, it will in general be figure out the yield. Regardless, like a human, if its feed an in the past unnoticeable model, the machine encounters issues to expect the result. The

essential objective of AI is the learning stage and derivation stage. Above all, the machine will learn through the revelation ofthe models. This divulgence is made us to offer significant thanks to the data. One fundamental piece of the data scientist is to pick mindfully which data to provide for the machine. Fig 4 shows the learning stage and The machine uses some excessive estimations to chip away at reality and change this exposure into a model. Subsequently, the learning stage is usedto depict the data and wrapped up it into a model Inferring is

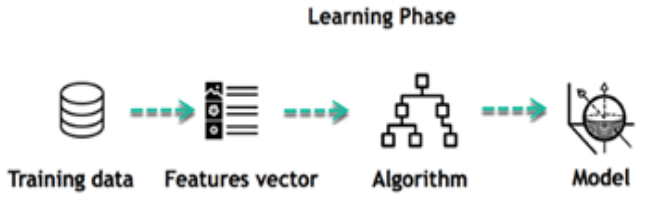

Fig 4 Learning Phase

another state in machine learning where the model is built, it is possible to test how heavy it is on never-seen-before data. The new data are changed into a features vector, go through the model and give a assumption. This is all the colorful partof machine learning. There is no need to update the rules or train again the model. we can use the model previously trainedto make inference on new data.

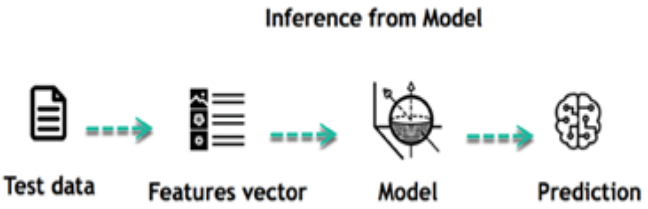

Fig 5 Inference from the Model

Fig 5 shows that there is no need to update the rules or train again the model. You can use the model previously trained to make inference on new data.

B. Types of machine learning:

Machine learning can be classified into two kinds of learn- ing tasks: Supervised and Unsupervised. There are many otheralgorithms.

➢ *Supervised learning:*

A calculation utilizes preparing information and evaluation from people to become familiar with the association of given contributions to a given yield. For instance, an individual can utilize promoting cost and climate figure as information to figure the deals of jars. We can utilize directed realizing when the yield information is known. This calculation will going to envision new information. There are two types of supervised learning:

- *Classification*:

Imagine we really want to expect the gender orientation of a person for a business. We will start by assem- bling the data on the stature, weight, work, pay, purchasing holder, etc from our singular informational collection. Weknow the sex of all of our individual, it must be male or female. The necessary focus of the classifier will be to give a probability of being a male or a female (i.e., the imprint) considering the information (i.e., features we have collected). We can utilize the new information to make a forwardness.

For instance, we have actually got new data from a dull individual, and we need to know whether it is a male or female. Acknowledge the classifier predicts male = 70 percent, it guesses that the calculation ensures at 70 percent that this individual is a male, and 30 percent is a female.The name can in like way be of no under two classes. The above Machine learning model has just two classes, yet expecting a classifier needs to anticipate object, it has so many of classes (e.g., glass,pen, table, shoes, and so on everything watches out fora class).

- *Regression*:

When the yield is rigid worth, the errand is a relapse. For instance, a monetary examiner might haveto predict the worth of a stock dependent on a scope of component like value, past stock exhibitions, macroeconomics file. The framework will be prepared to measure the cost of the stocks with the most in- conceivable blunder.

➢ *Unsupervised learning :*

In this unsupervised learning, an algorithm surveys input data without being given an explicit output variable (e.g., explores customer demographic data to predict the patterns) we can use it when you do not know how to categorize the given data, and we want the algorithm to find out the patterns and classify the data.

C. Graph Neural Networks:

Graph neural network (GNN)[9] is a class of neural net- works for processing data represented by graph data structures. They were well known by their use in supervised learning on properties of various molecules. Charts or the graphs are atany place around us. Our relational association is a model for outline of people and relations. The roads you take to go from guide c toward point d build up a chart. The associations that partner this site page to others structure a graph. Right when your manager pays you, your portion goes through an outline of money related foundations. Basically, whatever is solidified of associated substances can be called as a graph. Graphs are very incredible inventions to visualize relationship between people, items, and thoughts. Also past envisioning information, not with standing, diagram can moreover be for the most part brilliant wellspring of data to plan AI models for absurd undertakers. Graph neural networks (GNN) are a type of machine learning algorithm that can extract essential informa- tion from graphs and make useful assumptions. With graphs becoming more prevalent and richer with information, and artificial neural networks becoming more popular and capable, Graph neural network have become a powerful tool for many important applications.

➢ *Types of GNN:*

Two types of GNNs are Mostly Dominant:

Graph Convolutional Network (GCN) and Graph Auto- Encoder Network (GAEN) Let us understand them in detail:

- *Graph Convolutional Network:*

GCNs calls to the process of applying a spatially moving filter on the nodes of a graph that include embeddings or data related to each node to get a feature representation of each node. To include input from wider neighborhoods,various convolutional layers, similar to a standard CNN, can be put together.

- *Graph Auto-Encoder Network:*

Auto-encoders are neural networks that integrate two networks:an encoder that down- samples the contribution by moving it through convolutional channels to give a smaller element portrayal of the picture, and a decoder that accepts the encoder's translation as information and attempts to recreate the information dependent on it.Chart auto-encoders aim to appreciate a visual layout of the diagram and afterward re-build the chart by using the decoder. They might be utilized to learn chart embeddings and accordingly expect embeddings for concealed hubs and classify fresher hubs into existing classifications inside the organization.

➢ *Applications of GNN:*

We can see so many real life applications of Graphical Neural Networks like recommender systems, natural sciences, posts prediction, etc. The listed below are some of the applications of GNN:

- *Graph Classi- Fication:*

The essential point here is to segment the outline into various social events. It resembles picture request, except for the genuine developments to the graph space. Outline portrayal has a wide extent of vocations, from identifying whether or not a protein is a synthetic in bioinformatics to requesting articles in NLP or casual local area assessment and investigation.

- *Node Classification:*

The primary point here is to partition the diagram into different gatherings. It's like picture order, with the quirk of the objective movements to the diagram space. Diagram characterization has a wide scope of employ- ments, from recognizing whether or not a protein is a chemical in bioinformatics to ordering articles in NLP or informal community examination and exploration.

- *Link Prediction:*

In this case, the algorithm must comprehend the link between entities in graphs and attempt to forecast if two entities are connected. It is critical in social networks to infer social connections or to recommend potential buddies to users. It's also been used to solve recommender system issues and forecast criminal connections.

- *Graph Clustering:*

It refers to data clustering in the form of graphs. On graph data, there are two unique types of clustering. Vertex clustering tries in organizing the network nodes into clusters of highly linked areas based on edge weights or edge distances. The second type of graph clustering considers graphs to be the objects to be grouped and groups them based on similarity.

- *Graph Visualization:*

It is a part of math and software engineering that joins mathematical chart hypothesis with data representation. It is centered around the visual portrayal of charts, which shows constructions and irregularities in the data and helps the client in understanding the diagrams. There are many applications in GNN in which we have implemented Node classification in this work.

➢ *Node Classification:*

Node Classification is a very com- mon machine learning task to try in graphs: training a model to learn in which class a node belongs. GDS will train the supervised machine learning models based on node properties and characteristics (features) in our graph to forecast what class an unknown node or future node would belong to. Node Classification can be used likely together with pre-processing algorithms. Actually, Node Classification models are utilized to figure the non-existing hub property dependent on the other hub properties. The non-existing hub properties address the class, and is referenced to as the objective property. The characterized hub properties are utilized as info highlights.

The preparation cycle follows this means: The info chart will part into two sections: the train diagram and the test chart. The train chart is again separated into various conformity overlap, each folds comprises of a train part and an approval part. Each model competitor is prepared on each train part and determined on the separate approval part. The preparation interaction utilizes a strategic relapse calculation, and the computation utilizes the predefined measurements. The main measurement is the essential measurement. The model with the most elevated normal score whose as indicated by the essential measurement will win the preparation. The triumphant model will be then be retrained on the whole train diagram. The triumphant model is assessed on the train chart just as the test diagram.

The triumphant model is retrained on the whole unique chart. What's more, At last, the triumphant model will be enlisted in the Model Catalog. Prepared models may then be utilized to anticipate the worth of the designated property that is of before hand inconspicuous and obscure hubs. Not with standing this expectation of the class for every hub, the anticipated likelihood for the each class may like wise be there. The request for the probabilities match the request for the classes enrolled in the model.

D. Gap Analysis:

In this section, we have referred some papers related to node classification using GNN and we have provided overview of it.

Sakthi Kumar et al in their paper [2], performed node classi- fication tasks using spectral and non-linear approaches providing a outline representing the network. The models which are trained using network-dependent node features may not theorize to other networks.And the methods like Graph At- tention Networks (GAT) are not able to consider higher-order neighborhood information without rising the number of neural network layers. To overcome this restriction, they have used kernel propagation graph neural network (KP-GNN). It has a pre-handling step by which one can the get the high-request node information. This has a technique called Hadamard- product attention mechanism which reduces the number of hidden parameters by half therefore balancing the losses during training and validation. This allowed GNNs not to be dependent of node features when they are unavailable/missing and while available it increases the performance of GNNs because in this model node features can be replaced with higher-order structural features without loss of classification accuracy. Cora, citeseer and PubMed networks in conjunction with OGB networks are utilized in their work and hyper boundaries, for example, dropout rate and weight rot are setted.

- *After Preparing and Approval they Got the Accompanying Outcomes:*

- Attention mechanism used helped them prevent model fitting over (training loss is remarkably lower than validation loss). By utilizing AKP-GCN they summed up hole among approval and testing correctnesses is minor.
- In Cora and PubMed network, structural features when combined with node features can improve node classification.
- This approach on ogb-things organization, which is a business association can additionally foster the node portrayal accuracy of GCN by generally 3.5 percent.

Jie Zhou Ganqu Cui et al in their paper [5] worked on the four open problems indicating the major challenges and future research directions of graph neural networks, including robustness, interpretability, pretraining and complex structure modeling. They have taken dataset-ImageNet and it contains 3000 to 20,000 nodes. In the new occasions, graph neural networks have become amazing and viable instruments for AI assignments in diagram zone. This progress owes to advances in expressive power, model elasticity, and training algorithms. In this survey, they conducted a extensive review of graph neural networks. For GNN models, they have introduced its alternatives categorized by computation modules, graph types, and training types. Moreover, they also summarized several general frameworks and introduced several theoretical analysis. In terms of application cytology, they divided the GNN applications into structural framework, non-structural framework, and other frameworks, then they given a detailed review for applications in each scenario.

Inneke Mayachita et al in their work[7], training graph convolutional networks on node classification task text Clas- sification approach problem work well if there are enough labeled but unfortunately, in real world cases, labeling data might be expensive. They took the dataset-CORA reference network dataset. Implementation of Graph Convolution Net- works (GCN) by making use of Spektral API, which is aPython library for diagram profound learning dependent on Tensorflow. They performed Semi-Supervised Node Classifi- cation using CORA dataset. In the above parts we have gone over CORA reference network dataset. Conclusion from their work is that the conventional machine learning procedure to perform document classification, for instance CORA dataset, is to use supervised text classification approach. Graph Con- volutional Networks (GCNs) is an alternative semi-supervised procedure to solve this problem by seeing the documents as a network of related papers. Utilizing just 20 marked nodes for each class, GCNs beat Fully-Connected Neural Networks in this paper.

*Ziwei Zhang et al*in their survey[4] on the topic deep learning on graphs reviewed the various types of deep learning methods on graphs. They gave outlines of the techniques such as graph recurrent neural networks, graph convolutional networks, graph autoencoders, graph reinforcement learning, and graph adversarial methods.Graph RNNs which can cap- ture looping and subsequent patterns of graphs. They are seperated into two categories- node-level RNNs and graph- level RNNs.Graph RNN can also be combined with otherconstructions ,such as GCNs or GAEs.By using GCN , useful node features can be learned to solve many node-focused tasks and node information needs to be combined to perform graph-level tasks.The GAE along with its variations have been widely applied in unsupervised learning tasks and are suitable for learning node representations for graphs.Reinforcement learning (RL) is known to be good and acceptable at learning from feedbacks.DeepPath and MINERVA which are the rein- forcement learning method are both adopted RL for knowledge graph (KG) reasoning.They found that DeepPath targeted at finding the most information by giving path between two target nodes and MINERVA found the right answer node given a question node and a relation.So by this survey they showed that deep learning on graphs is a promising and booming research field that brings exciting and challenging oppurtunities.

Keyulu Xu et al in their survey[10] on the topic how powerful are graph neural network have explained the graph neural networks and even they have showed how Graph Neural Net- works (GNNs) are an effective framework for representating learning of graphs. At the point when we investigate the over all survey of this paper , we can find how GNNs follow a neighborhood aggregation scheme, where the representa- tion vector of a node is computed by recursively combining and transforming representation vectors of its neighboring nodes.Numerous GNN variations have been proposed and have accomplished

progressed results on both node and graph classification techniques.

However, despite GNNs transforming graph representation learning, there is limited understanding of their representa- tional properties and limitations. They presented a theoreti-cal framework for analyzing the strong power of GNNs to capture different graph structures.Their results characterized the inequitable power of popular GNN variants, such as Graph Convolutional Networks and Graph SAGE, and showed that they cannot learn to distinguish certain simple graph structures.Then they developed a effortless architecture that is likely the most expressive among the class of GNNs and is equally as powerful as the Weisfeiler Lehman graph isomor- phism test.Then, at that point, they tentatively approve their hypothetical discoveries on number of graph classification benchmarks, and exhibit that their model acheived state-of-the-art(advanced) performance.

III. SYSTEM MODEL

➢ *System Architecture:*

- *Description of each module:*

✓ *Data collection:*

The dataset we put forward for this project has been taken from Cora. But this data set is in raw format. The data set consists of 2708 scientific publications consisting of 7 labels or classes .The initial step is to convert raw data into processed data which is done by normalization process, since the raw data collected have multiple attributes but only some of those attributes are needed for the prediction.

✓ *Data Processing:*

Information or data preprocessing in Machine Learning is a significant advance that works on the nature of information to advance the extraction of significant perception from the information. Information preprocessing in Machine Learning alludes to strategy of getting ready (cleaning and putting together) the crude information to make it appropriate for a structure and preparing Machine Learning models. In basic words, information preprocessing in Machine Learning is an information mining method that changes crude information into a reasonable and decipherable configuration. It is the initial step denoting the commencement of the inter- action in machine learning.Typically, certifiable information is deficient, conflicting, incorrect (contains blunders), and needs explicit trait esteems/trends.This is the place where information preprocessing enters the situation it assists with cleaning, design and sort out the crude information, in thisway making it ready for Machine Learning models.

The below fig 6 represents the flow of the model.

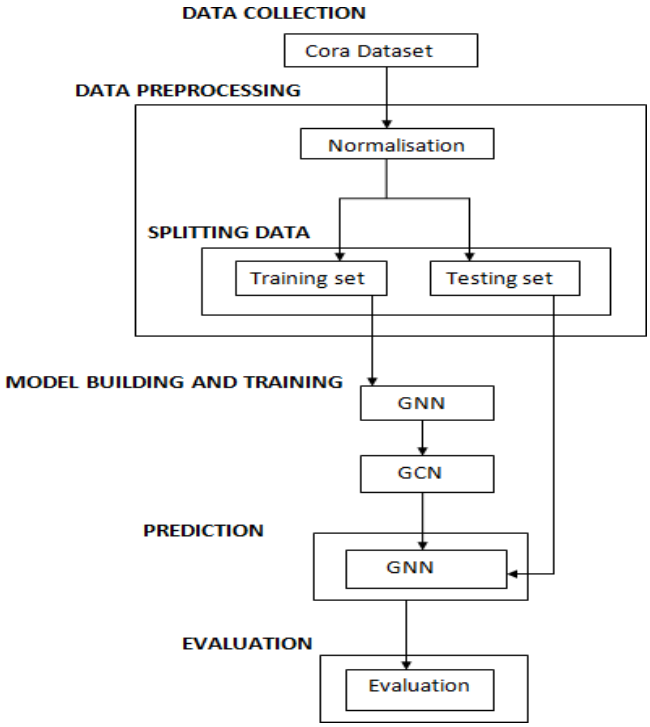

Fig 6 System Methodology

In our model, we normalized the features using torch geometric's transform functions.

✓ *Splitting data:*

The train-test split strategy is utilized to appraise the exhibition of Machine Learning calculations when they are utilized to make expectations on information not used to prepare the model. The strategy includes taking a dataset and partitioning it into two subsets.Train information and Testinformat ion. *Tr Data:* Used to fit the machine learning model. *Test Data:* Used to evaluate the machine learning model.The objective is to check the display of the machine learning model on new datar model , the imprints are encoded as numeric worth between 0-6. There are 20 centers for each class which contain twofold test, train and endorsement masks(they let usein on which center point can be used for which task). Dropout is simply applied in the readiness step, but not such a huge amount for expectations [21].

✓ *Model Building and Training:*

Pytorch Geometric which is a mathematical profound learning library is utilized for building diagram network. Pytorch Geometric permits us to utilize distinctive chart neural organization layers inside Py- torch module. Graph Convolutional layer(GCN) is the layer which performs message passing. We have 2 Message Passing Layers since we have utilized 2 message passing advances andone Linear yield layer which yields the likelihood of 7 classes.

By applying dropout we ensured no information is lost when performing prediction. Rectified Linear Archictecture workapplied for better execution ,it yields the information if

the information is positive or it gives zero if the information is negative. The softmax work is utilized as the enactment work in the yield layer of neural organization models that anticipate a multinomial likelihood appropriation.

✓ *Prediction:*

The output of the model are 7 probabilities, one for each class. For each of the node, we can get the prediction. Here, 95 percent predicted that the node is class 2 and small prediction that its class 0, 1, 5 and for others the prediction is 0. The class with highest probability will be chosen as our predicted class. Here it is class 2.

IV. EXPERIMENTAL DETAILS

➢ *Experimental Setup:*

In this section, we briefly explained the libraries which we have used in our experiment. Torch is an open-source AI library, a logical figuring framework. Torch nn help us in mak- ing and preparing of the neural network. Torch.nn.functional incorporates relu (rectified direct initiation work for neurons). GCNConv-diagram is the convolutional layer which performs message passing. Seaborn is the information representation and exploratory information analysis. Numpy is the mathe- matical python library for performing numerical procedure on arrays. Planetoid is the chart based semi-regulated learning method. transforms is used for performing normalisation on data. Initially we install the Pytorch Geometric which is a geometric deep learning library used to build graph networks then loading the cora dataset for performing the node classi- fication.

➢ *Dataset:*

Overview of Cora dataset: The number of graphs are 1, number of features are 1433, number of classes are 7, Data(x=[2708, 1433], edgeindex=[2, 10556], y=[2708], train- mask is 2708, valmask is 2708, testmask is 2708), number of nodes are 2708, number of edges are 10556, number of training nodes are 140, training node label rate is 0.05 and itis undirected.

V. RESULTS

➢ *Training and evaluation of the model:*

Epoch indicates the number of passes of the entire training set. Cross entrophy loss is a loss function used in machine learning. The smaller the loss the better the model. Here, the loss has decreased from 1.9461 to 1.3365.

➢ *Loss visualization in graph:*

As the epochs increases, we can observe that the loss has been decreasing in the fig 8.

➢ *Test accuracy:*

Using the test function we can get the test accuracy.In our experiment,we got 74 percent accuracy i.e. three-forth of the predicted class is correct.

Figure 7 is the result of the experiment.

Epoch	Loss
000	1.9461
100	1.8616
200	1.7218
300	1.6939
400	1.6404
500	1.5224
600	1.4699
700	1.4313
800	1.3785
900	1.3582
1000	1.3365

Fig7 Result Table

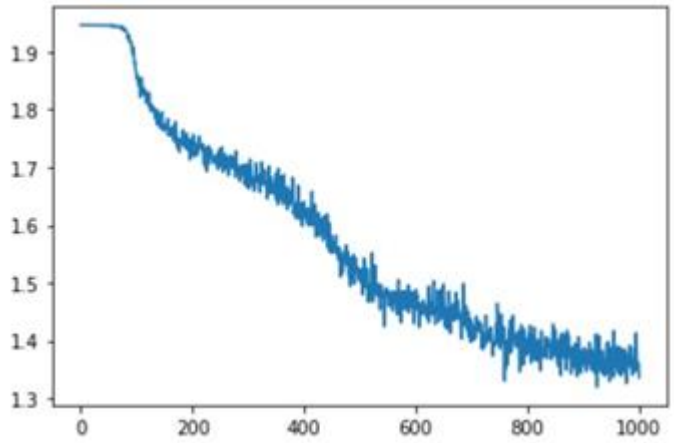

Fig 8 Loss Visualization in Graph

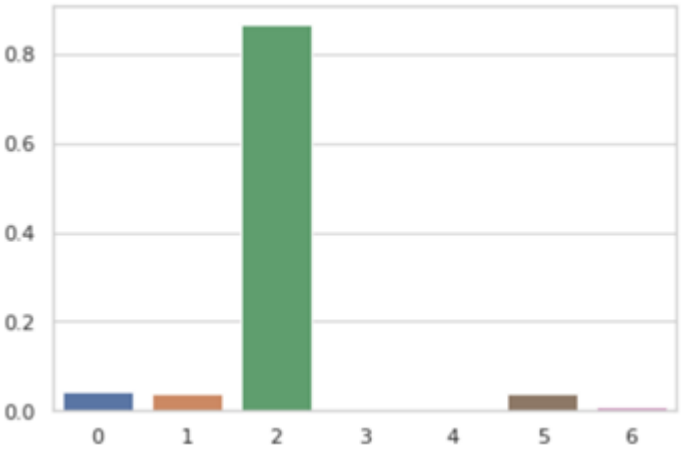

Fig 9 Output of the Model

➢ *Output of the Model:*

In our experiment, 95 percent predicted that the node is class 2 as the graph shown in Fig9 and small prediction that its class 0, 1, 5 and for others the prediction is 0. For every node we can get prediction in this way. The class with highest probability will be chosen as our predicted class. Here it is class 2.

➢ *Visualizing the Embeddings with TSNE:*

TSNE is an un- supervised, non-linear technique primarily used for data explo- ration and visualizing high-dimensional data. It shows how the data is arranged in a high-dimensional space. Here we fit the TSNE with our node embeddings. We reduce the dimension of node embeddings to a 2 dimension as we cannot visualize our embeddings of dimension 16. For every 50 epochs, we showed how the node embeddings looks like. TSNE Visualization: X-axis: 1st dimension of dimensionality-reduced embedding Y-axis: 2nd dimension of dimensionality-reduced embedding Points = nodes (embeddings) Colors=classes/labels. We coloredthe class so that all nodes with the same class will have same color. Here in the Fig 10, we can see initially for epoch 0,

Fig 10 Initial Visualization of Node Embeddings

we have node embeddings spreaded all over the place. Over the time, GNN improved, we can see their are some

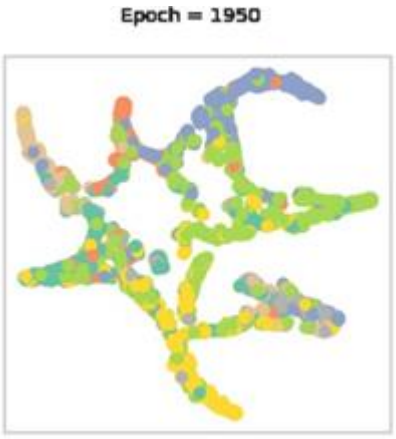

Fig 11 Final Visualization of Node Embeddings

clusters i.e. classes with same node embeddings appear in the same area. So now we have perfect clustering which will allow us easily to predict the classes for new data points(nodes) as shown in the Fig 11.

VI. CONCLUSION

This paper work shows that using graph neural networks,we can easily perform node level classification, which tellsus to which class the node belongs to. These techniques will be useful in real world application like citation networks, youTube videos where user can get the recommendations based on the previously viewed content by user. Here, we performed node classification on Cora dataset, processed our model, trained it and got output which indicates that 95 percent predicted that the node belongs to class 2 and small predictionthat it's class 0, 1, 5 for other classes, prediction is 0. Theclass with highest probability will be chosen as our predicted class. Here, it is class 2. Using TSNE, we visualised the node embeddings. Over the time, GNN improved, we can see presence of clusters, which allows us to easily predict classes for new nodes.

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