**SIGNAL PROCESSING PROJECT REPORT**

Discrete Signal Processing on Graphs: Frequency Analysis

**Basic Idea of paper:**

The basic Idea of our paper is to apply conventional signal processing techniques to major real-life problems with the help of Graph Signals in the Graphical domain. Our basic plan would be to consider a situation, analyse it based on its graph using signal processing techniques, make observations, and report on it.

\*All the complex data has been omitted in the report to make it readable and simple.

**Graph Signals - Models and Uses:**

Graph Signals can be extracted from many systems or networks around us. It is a bevy of nodes connected. Graph primarily are represented by the two parameters G = (V, A) where V is the vertices of the graph, and A is the adjacency matrix for the connections between the nodes. Where V is represented as a row matrix, V = [v0, v2, v3……., Vn-1] and the adjacency matrix is nxn matrix. Where An, m is the weight of the directed edge Vm to Vn. In specific cases when the graph is undirected, the weights Am, n and An, m will be same. Now using the above graph, we construct a dataset ‘**s**’ known as **Graph Signal**.

Now, this is the signal we will be working on. This ‘**s**’ contains the data we obtained from the graph but in complex domain. We can perform all the required actions on this graph signal.

There are many networks which can be used as input to the Graph Fourier Transform and get outputs. We can give many connected systems as input, the connections between neighbours basically give us an overview of the relations or the extent of the connection between the neighbours. This is a very important factor/data, when we have a massive network of nodes, we can use this data in in numerous ways.

•We can figure out all sorts of statistical data such as averages, variances etc.…

(**Data Classification**)

•This graph Signal Models can also be used in **failure detection** as there are many nodes, if the values from neighbouring nodes vary with a large value, we can conclude that the data from the nodes which differs with a huge value is erroneous.

Above are two simple everyday applications of Graph signals, many more complex and astonishing results can be reaped.

**Methods/steps used in the analyzation:**

So basically, to analyse the situation we use our traditional signal processing techniques in graphical domains. We use most of our traditional techniques with slight workarounds which lead us to usable forms of our transforms or series, in graphical regime. While using the graph signal processing techniques, we need to visualize the situation as a graph signal with N nodes and M connections between the nodes. This would represent our situation in terms of a graph signal on which we can apply our signal processing techniques. Now when we have our graph signal in time domain, we convert it to the frequency domain (Fourier transform) as analysis is easier in this domain compared to time domain.

Having our graph signal in frequency domain, we have many ways of analysing this graph.

* Depending upon the Total Variation of the signal we may get information about the nodes in the graph signal.
* We may send this signal as input to an LTI system having appropriate frequency response and analyse the graph signal based on the output of the LTI system.
* We may also design a filter that filters out unwanted frequency components from the graph signal and gives us Idea about the nodes which are not required, or which are malfunctioning.

**Models we are considering working on:**

Graph signal details were heavily mentioned in the previous sections as it is the basic building block for the whole of the paper. Now from our observations we could land upon many such graph signals around us. After we started looking in a specific angle, we found out that many common life situations could also be modelled with graphs. Analysis on them can be performed very effectively and efficiently.

The few models we found interesting are mentioned below

* We have many temperature/humidity sensors placed in and around our campus which sense data. But over the course of time few sensors might start to malfunction, so to find out the defective one we can use our native signal processing techniques with slight workarounds developing an everlasting solution.
* Image compression is a phenomenon highly used from day to day. According to our paper we can also consider neighbourhoods in a graph and use them in our analysis now, we can map a neighbourhood to a value hence massively reducing the amount of data to be stored. Here Graph filtering is used extensively

We plan to work on any of the above model and completely apply graph signal processing techniques from the scratch and re-iterate the righteousness of theoretical propositions with practical values.

**Further plans and implementations pending:**

The basic “read and understand” cycle of the paper has been done to a good extent. To start with, we plan to thoroughly present our views and understandings of the paper theoretically.

Then as mentioned in the above sections, we plan to take a practical, real-life example to justify the theory with practical values and step by step mathematics to portray better the work done and highlight the massive gains which can be obtained by using Graph Signal processing.

Further If time permits, we would like to code up the mathematics using Graph Signal Toolbox in MATLAB to highlight the findings in visual depictions for even better reach and grasp of the concepts.

**References:**

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