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SIT724- Research Presentation ENERGY DISAMBIGUATION- THESIS

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Problem Statement & Motivation

- In recent years there has been an increased usage of affordable individual smart plugs as opposed to purchasing a smart metre for the entire house, this is because you would have access to the energy consumption of each individual device. It is common for almost all households to use extension cords or extension adapters to connect multiple appliances to one electrical socket. This is where the problem arises with smart plugs and what this report is based on, the purpose of individual device consumption is lost when multiple devices are connected to a single smart plug.



Existing Literature

There are various approaches that can be taken to solve the problem of disaggregation, commonly done by machine learning algorithms for the purpose of assisting households minimise their energy consumption. A lot of prior research has focused on smart homes and smart meters that record data of an entire household or building whereas my chosen topic is to desegregate aggregated power data collected from random devices through the means of a single smart plug.



Objectives of the Research

- To examine and evaluate existing literature and identify literature gaps
- Collect data using a smart plug and smoothen the data to remove any outliers and be able to perform energy disaggregation methods in an efficient manner.
- Construct a design and evaluation plan that aims to address the main research questions that has been established in the report



Design

- This research is divided into 2 phases, the first phase is where detailed literature review took place, collecting raw data from devices separately and together as an aggregated power source. The data processing included a smoothing process and cleaning up the data to be used for disaggregation algorithms. Phase 2 is where the implementation of the algorithms occur and deep analysis on the 2 algorithms being used to execute the disaggregation process which is GSP and PrunedNILM



Artefact – Phase 1

Phase 1 includes:

- Detailed research on state of the art
- Data collection application on python
- Smoothing of data and detailed evaluation



Artefact – Phase 2

- Phase 2 of this project is where the pattern recognition and the actual disaggregation of Energy data takes place. There are 2 distinct approaches, GSP and PrunedNILM which is evaluated and analysed separately. The reason for using different datasets is due to the fact that GSP does not need a huge chunk of data, which is why the data being used is the one that was collected. However to perform a machine learning algorithm, huge amount of data is required in order to train and test the data, hence a public dataset is used for Pruned-NILM.



Graph Signal Processing

- GSP is based on graph signals, which are found by indexing a dataset by a graph's nodes. The primary concept is to visualise a dataset using a graph made up of a number of nodes and a weighted adjacency chart, each of the graph's nodes represent an element in the dataset.
- GSP is utilised three times for the disaggregation of an active power signal: once for robust event detection, once for clustering, and once for feature matching. The approach is event-based and relies only on time-series data without any training.

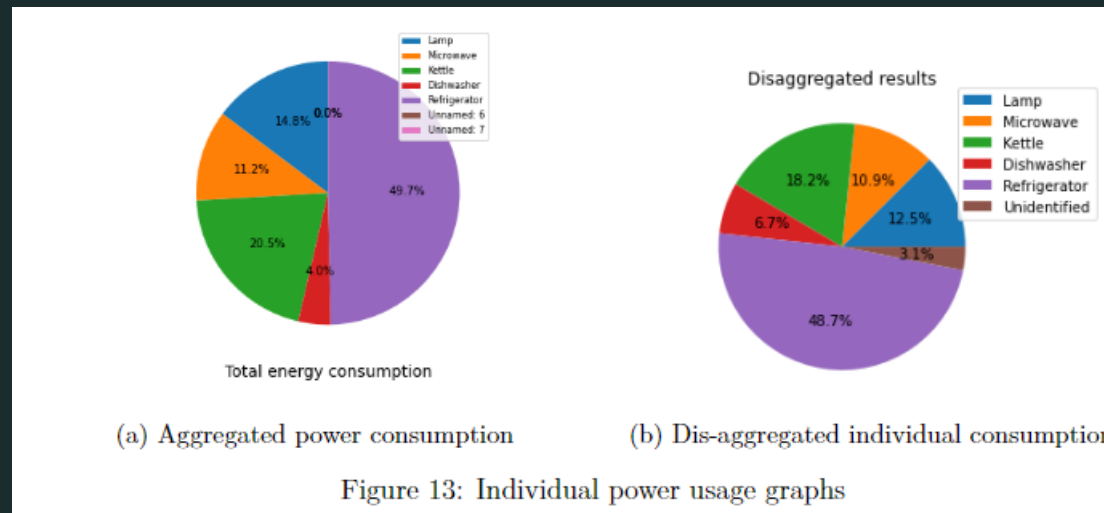


Pruned-NILM

- The essence of pruning refers to removing extraneous values from the weight tensors. In order to eliminate what we is believed to be pointless connections between the layers of a neural network.
- There are 4 pruning techniques that are investigated in this paper:
 - Entropy-Based Pruning(EBP)
 - Relative Threshold Pruning(RTP)
 - Structured probabilistic pruning(SPP)
 - Constant Sparsity Low Magnitude Pruning



Evaluation - GSP



The disaggregation error between the algorithm and the ground truth signatures is 5.3%



Evaluation - PrunedNILM

The total number of trainable weights: 30,708,249

	EBP	RTP	SPP	LMP
No. of weights	21,251,411	18,479,487	30,695,431	9,239,743

Table 1: The 4 pruning methods applied to the Sequential-to-point Model: Entropy-Based Pruning (EBP), Relative Threshold Pruning (RTP), Structured Probabilistic Pruning (SPP), Low Magnitude Pruning (LMP)

Mean Square Error (MSE)

Appliance	EBP	RTP	SPP	LMP
Kettle	0.1153	0.1272	0.0993	0.1105

Table 2: Mean Square Error for each of the pruning methods with the Kettle

Mean Absolute Error (MAE)

Appliance	EBP	RTP	SPP	LMP
Kettle	0.0768	0.08214	0.0644	0.0728

Table 3: Mean Absolute Error for each of the pruning methods with the Kettle

Ranking of methods according to the results:

1. SPP
2. LMP
3. EBP
4. RTP



Performance Matrix

Appliance	TP	FP	TN	FN	PR	RE	FM
Kettle	37	3	0	2	0.93	0.95	0.94
Lamp	16	7	1	3	0.84	0.8	0.82
Monitor	15	7	2	2	0.75	0.79	0.77
Laptop	29	27	7	11	0.59	0.62	0.6

Table 4: Performance of the approach with data collected

Appliance	TP	FP	TN	FN	PR	RE	FM
Microwave	12	0	8	4	1.00	0.50	0.67
Kettle	43	3	7	0	0.93	0.86	0.90
Freezer	51	88	15	20	0.37	0.59	0.45
Refrigerator	22	84	12	1	0.21	0.63	0.31
TV	9	5	2	3	0.64	0.64	0.64
Washing Machine	7	4	0	1	0.64	0.88	0.74

Table 5: Performance of the approach with a single house power usage from the REFIT data-set



Conclusion

- Results and analysis clearly proved that both methods are well constructed and are suitable for energy dis-aggregation with both short term low volume data as well as long term high volume data with different algorithms which can be chosen according to your dataset and requirements.
- GSP is much faster and involved no training or testing at all and comparatively less complex, whereas Pruned-NILM can handle extremely large datasets and uses sequence-to-point and NILM toolkit which is a proven machine learning algorithm that has been in use for many years.



Potential

- There is a lot of potential in the field of energy disambiguation especially with the recent awareness of climate change and the hike in energy prices, more people are interested in the statistics of their energy usage and in turn would allow more individuals to help reduce energy wastage.



THANK YOU

