

PAPER • OPEN ACCESS

UAV based Mapping System for Precision Agriculture

Recent citations

- [Aakashjit Bhattacharya and Debashis De](#)

To cite this article: S. Sheeba Rani *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **937** 012035

View the [article online](#) for updates and enhancements.



ECS **240th ECS Meeting**
Oct 10-14, 2021, Orlando, Florida

**Register early and save
up to 20% on registration costs**

Early registration deadline Sep 13

REGISTER NOW

UAV based Mapping System for Precision Agriculture

S.Sheeba Rani¹, J.Janet², K.C.Ramya³, R. Sitharthan⁴, T.Kesavan⁵, S Shrivastava⁴

1 Associate Professor, Department of EEE, Sri Krishna College of Engineering and Technology, Coimbatore

2 Professor, Department of CSE, Sri Krishna College of Engineering and Technology, Coimbatore

3 Associate Professor, Department of EEE, Sri Krishna College of Engineering and Technology, Coimbatore

4 School of Electrical Engineering, Vellore Institute of Technology and Science, Vellore

5 Assistant Professor, Department of EEE, Sri Krishna College of Engineering and Technology, Coimbatore

E-mail:sheebaranis@skcet.ac.in

Abstract. Agriculture the backbone of our nation as well many nations is essential to feed the people and smart farming is the much-needed disruptive technology to help the farmers increase their yield. Airborne vehicles and relays supplement the automation system to monitor the growth of the plants, individually and record the observations to estimate the level of pesticides and herbicides to be applied. However, there are no simulation platforms designed to help these farmers to collect and process the data gathered. The proposed work consists of a sensor fusion framework that will give the user a complete farming scenario which is focused on data gathering with airborne UAV or relay mechanism, line of sight deployment, coverage area, identify sensor placement, and usage of fog computing paradigm as a backend computing support. The paper focuses on providing an evaluation benchmark for energy consumption, system resource usage, packet delivery ratio and transmission delay.

1. Introduction

As technology advances, many digital ways for enhancing agriculture have been used over the past decades [1]. These inventions are generally focused on enhancing the productivity of crops by collecting and analyzing agricultural land. This process is accomplished with the use deployed sensors. Internet of Things is adopted for precision agriculture and gathering of information which is further used for decision-making based on the data. The presence of fog has paved way to many new challenges in smart agriculture.

It is therefore crucial that we devise a system with sensor deployment to obtain the maximum yield in precision farming. But, the performance of the system will be affected due to many issues faced by the sensors. When the sensors are used to gather data, it is found that they consume more energy due to continuous periodic usage which reduces the network lifetime, overall [2]. Hence, it is essential to employ an informed deployment system that can survey the complete land for smart farming applications, in order to reach the desired goal.



In today's development in smart farming, there are many works which make use of actual deployment that doesn't use prior knowledge leading to improper utilization of the resources. Based on surveys, it has also been observed that there are very limited toolkits developed which exists designed solely for the development of smart farming coupled with network configuration species. Some studies show that actual sensors [3] are used in emulated models for decision making with data obtained. However in these network properties, there are couple of things that are ignored such as energy consumption of underlying communication model, overlapping regions of deployed sensors leading to network congestion, and packet rate error.

Moreover, there are very limited framework which enables data processing in fog locations. To overcome these issues, there is need for developing a smart-farming simulation stack that also supports sharing and backend computing environments. Data driven modern sensor deployments are being employed in the recent years. This method is focused on not just monitoring the land, but also for intervention of the user depending on the situation analysis made through observation of the situation [5-15]. The development in high-speed networks and quick accessibility of the edges using cloud has increased the efficiency of the system, thereby increasing the productivity. The following are the important features of the toolkit:

- Use of different mobility models to support mobile and static sensor deployment. The sensors are specifically designed in terms of storage, data rate, transmission range and network parameters.
- Offers support for sensor energy models to give an overview of the realistic scenarios based on the simulation results.
- To support gathering of data using UAVs, a complete data of the UAV configuration has been inbuilt.
- Facility to use non-relay-based and relay based data communication mechanisms.
- Uses a broker who is used to collect UAV data which is further communicated with the other brokers to execute the scheduled policies based on analysis.
- The fog computing concept is used for delay-sensitive applications
- Using the fog computing model in the backend, it provides early warning system and data-driven monitoring [16-20].

2. System Modeling

Consider 'F' to be a farm with 'L' as length and 'W' as width. The dimensions of the farm is represented by L.W and 'S' represents sensors. The system developed is built such that there are N heterogeneous sensors with varying transmission times T_s and energies E_s . At the location S_{xy} the sensors are either mobile deployed or are static [21-30]. They also used to communicate information, apart from sensing, to the central node. The UAVs are used to obtain data from the sensors and then use this data to be sent to the main server where it is analyzed and used in real-time. Every UAV used is configured with an energy E_u and communication range R_u . These two sensors are designed in such a way that they operate in two modes: active mode and sleep mode [31-35].

Total Energy consumed E_t is represented as

$$E_t = E_{active} + E_{sleep} \quad (2.1)$$

where E_{active} and E_{sleep} are the energies consumed in active and sleep modes, respectively.

Here,

$$E_{active} = E_{wup} + E_{msr} + E_{pcs} + E_{tmt} + E_{rcp} \quad (2.2)$$

$$E_{sleep} = P_{sleep} \cdot T_{sleep} \quad (2.3)$$

Where,

T_{sleep} = Time sleeping

P_{sleep} = Power consumption

E_{rcp} = Energy consumption for data reception

E_{tmt} = Energy consumption for data transmission

E_{pcs} = Energy consumption for data processing

Emsr= Energy consumption for sensing data measurements

Ewup= Energy consumption for wakeup

These energies are configured depending on the active duration and the frequency of the sensor processing unit. Data is gathered from M-UAVs and any interaction within the UAVs and the deployed sensors is done through uplink with OFDMA. 'K' simultaneous connections are supported by the UAVs for gathering information. Moreover, the system designed by us is programmed to share data between nearby fog/edge locations with UAVs [6]. There is possibility for high packet rate error occurrence as the deployed sensors are mobile. Hence Line of Sight (LoS) has to be fixed to enable effective communication.

The probability of Line of Sight is computed as follows:

$$pLoS = 1 / (1 + \rho * \exp(-\sigma[\Phi - \mu])) \quad (2.4)$$

Where σ and ρ are the constants depending on the type of area and communication frequency, Φ is the elevation angle between the UAV U_{xy} and the sensors S_{xy} .

As the altitude of UAV increases, so does the probability which indicates that if and only if the LoS probability is close to 1 and the deployed sensors are assigned to UAV j th such that Φ is $\geq pLoS$. Hence the this condition can be defined using the formula

$$d_{ij} \leq h_j / (\sin^{-1}(pLoS)) \quad (2.5)$$

Where,

h_j is the altitude of the UAV

d_{ij} is the distance between j th UAV and i th sensor node

If it is assumed that there are $m \times n$ sensors deployed, then t_c is the coverage time wherein UAVs is calculated as follows:

$$t_c = \sum_m \sum_n T_{mn} + \frac{2}{M} \sum_k \sum_j S_{kj} \quad (2.6)$$

Where,

S_{kj} is the number of sensors

M is the count of UAVs utilized for gathering data

T_{mn} represents the time required to move the Unmanned Aerial Vehicle from one sensor to the other

B brokers are used to keep track of the fog locations and are used for proper use of the available fog information near the end users. The resources for the neighboring locations are allocated by the broker. This will aid in decreasing the communication delay, thereby enabling IoT based delay sensitive application. The distance between the nodes is represented as the network delay t_d such that

$$t_d = d_a + d_b \quad (2.7)$$

Where,

d_b represents the delay between the assigned fog location and the UAV

d_a is the network delay between UAV and the sensor

The network cost is represented as C which is a linear function represented as follows:

$$C = \phi \cdot (d_{i,j} + \sum_{(k \in B \ \& \ j \neq k)} d_{(j,k)}) \quad (2.8)$$

Where,

$d_{i,j}$ is the distance between the local broker j and the i th UAV

ϕ is a constant and j

$d_{(j,k)}$ is the distance between the brokers leasing compute resources and the local broker $j \in B$

3. Proposed Methodology

The method proposed is based on INET5 and OMNet++4, which is the extension of FogNetSim++ [4]. An outline of the execution model is represented in the Figure X. The core modules are as described below:

3.1. Communication Module:

This module is made up of many devices and different features. The sensors used in this module are built to sustain short-range communication and hence their communication mechanism also differs. These sensors communicate with the nearby sensor nodes to exchange data which is in turn conveyed to the gateway node. This means of communication requires efficient planning. Surveys show many significant contributions in route planning for sensor nodes which employ overhead of data routing and leader election which will lead to the consumption of energy at a significant scale. To overcome this, we propose gathering of data using airborne vehicles. When the time to gather data comes, the UAV is triggered to alert the ground sensors and a connection is established between the two points. Data is shared by the sensors with the UAV and after sharing the data, the sensors discard the information [10]. Similarly, the data gathered using UAVs will impose new challenges. These conflicts are resolved using a callout mechanism devised instead of the traditional approach of leader-based grouping model. However, the proposed method is not economical in terms of energy. In the proposed work, the callout mechanism used will assume that prior information is saved in the UAV regarding unique identification number and deployed sensors. When the sensors are called out, the UAV sends request to the sensors which responds. This method can be further used in real time collaboration of UAV to UAV to gather data.

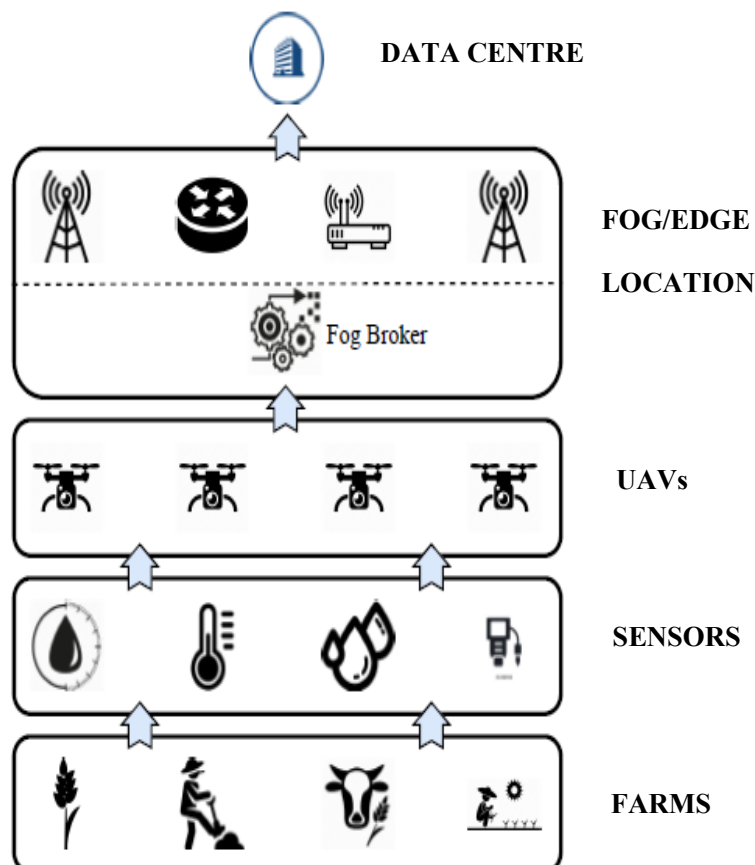


Figure 1. Layered Architecture of Toolkit for Smart Farming

3.2. Fog Nodes

These nodes are resources that are used to store, process and receive the information temporarily from the UAV streams. There are $q \in 1, 2, \dots, m$ fog resources at the fog location. Hence, depending on the real-time scenario, specification of every location can be configured accordingly [8].

3.3. Sensors

The proposed work makes use of mobile and static deployment to collect data real-time and increase farm productivity. The sensors are built with different battery life, storage and transmission ranges. These sensors are capable of forwarding the data to the neighbouring nodes using ad hoc ways. The figure X.2 gives an illustration of a sensor node. The UAVs are used too gather information from the mobile sensors and static sensors resulting in a mobile gateway node. In general, data is gathered by the sensors and forwarded to the gateway [7]. But, this will result in unnecessary wastage of energy during route finding and leader selection. To overcome this defect, a mobile gateway concept is employed by us which will increase the lifetime of the sensors and also optimize it for accurate data gathering. The limited storage availability and energy is also modeled accordingly. Figure X.2 represents the architecture of UAV.

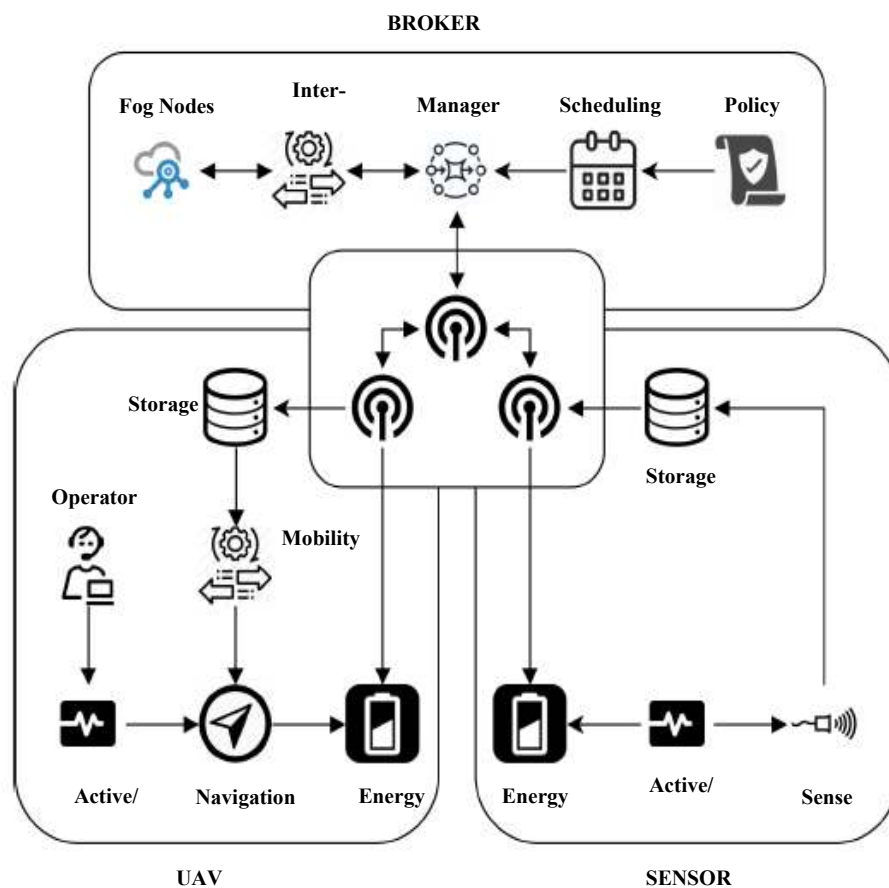


Figure 2. Internal Architecture

3.4. Broker

The fog resources are managed by the brokers and a broker is assigned for every fog location. There are M UAVs assigned to a fog location and broker nodes are used to administer these locations. These nodes further communicate with each other to find an apt resource for the UAV. At the fog location, the broker node is placed as a fixed entity as shown in the architecture, thereby managing scheduling and communicating with the fog nodes. Fault tolerance is enabled using a secondary which will kick in on failure of broker nodes do not reproduce well when printed out—your diagrams may lose vital information when downloaded and printed by other researchers. Try to ensure that lines are no thinner than 0.25 pt. Note that some illustrations may reduce line thickness when the graphic is imported and reduced in size (scaled down) inside Microsoft Word

3.5. Mobility Models

These modules enable movement of the mobile sensors in specific patterns. Though there are several static sensor deployed, the system is designed such that it supports the use of mobile sensors for various purposes. One such use is the utilization of UAVs to obtain information from the sensors on-ground. Vehicle mobility, linear mobility, circle mobility, mass mobility, nomadic community, column mobility, Gauss Markov and random way-points are some examples of mobility models that are support by the proposed framework [9]. There is also an option to extend the mobility models to suit the user requirements.

4. Results and Discussion

Evaluation of the proposed framed is carried out to analyse its performance in terms of UAVs and sensor energy consumption, transmission and processing delay, and system resource usage. UAVs are employed to gather information from the ground sensors. This data is then sent to the broker nodes which will allocate fog resources to perform the task completion. The tasks are generated as MIPs with the help of remote or local resources. Meanwhile, UAVs are also used to evaluate the transmission delay and packet delivery ratio which is important to measure the performance of the wireless sensors at a large-scale [11]. The proposed work also supports the use of fog nodes depending on the number needed by the user. Since the sensors are fixated to a particular location, it might fail due to loss of energy, which is the biggest drawback of the system. The track of fog devices that are available is maintained by the broker with the help of data gathered from the fog nodes.

5. Conclusion

It is observed that the simulation tools play a large part in supporting research in many fields. There are no such tools designed specifically for smart farming purpose and almost all the work is dependent on sensors. Moreover, users are also unaware of sensors congestion phenomena, transmission range and placement of the devices. Hence the proposed framework gives a complete farming ecosystem which is inclusive of fog location, UAVs and sensors. It will give the user access to gather data via sensor relays or UAVs, deploy sensors and also perform fog computation. The work carried out is also equipped with facility to measure transmission delay, energy of the sensor and packet delivery ratio. Future work can be carried out as an extension of this work by incorporating WCN using ANN for intelligent systems and big data analytics for smart farming.

6. References

- [1]. Sitharthan R, Geethanjali M and Pandey TKS 2016 Adaptive protection scheme for smart microgrid with electronically coupled distributed generations *Alexandria Engineering Journal* **55(3)** 2539-2550

- [2]. Fathima AH, and Palanisamy K 2014 Battery energy storage applications in wind integrated systems—a review *IEEE International Conference on Smart Electric Grid* 1-8
- [3]. Prabaharan N and Palanisamy K 2015 Investigation of single-phase reduced switch count asymmetric multilevel inverter using advanced pulse width modulation technique *International Journal of Renewable Energy Research* **5(3)** 879-890.
- [4]. Jerin ARA, Kaliannan P and Subramaniam U 2017 Improved fault ride through capability of DFIG based wind turbines using synchronous reference frame control based dynamic voltage restorer. *ISA transactions* **70** 465-474
- [5]. Sitharthan, R, Sundarabalan CK, Devabalaji KR, Nataraj SK and Karthikeyan M 2018 Improved fault ride through capability of DFIG-wind turbines using customized dynamic voltage restorer *Sustainable cities and society* **39** 114-125
- [6]. Prabaharan N and Palanisamy K 2016 A single-phase grid connected hybrid multilevel inverter for interfacing photo-voltaic system *Energy Procedia* **103** 250-255
- [7]. Palanisamy K, Mishra JS, Raglend IJ and Kothari DP 2010 Instantaneous power theory based unified power quality conditioner (UPQC) *IEEE Joint International Conference on Power Electronics, Drives and Energy Systems* 1-5
- [8]. Sitharthan R and Geethanjali M 2017 An adaptive Elman neural network with C-PSO learning algorithm-based pitch angle controller for DFIG based WECS *Journal of Vibration and Control* **23(5)** 716-730
- [9]. Sitharthan R and Geethanjali M 2015 Application of the superconducting fault current limiter strategy to improve the fault ride-through capability of a doubly-fed induction generator-based wind energy conversion system *Simulation* **91(12)** 1081-1087
- [10]. Sitharthan R, Karthikeyan M, Sundar DS and Rajasekaran S 2020 Adaptive hybrid intelligent MPPT controller to approximate effectual wind speed and optimal rotor speed of variable speed wind turbine *ISA transactions* **96** 479-489
- [11]. Sitharthan R, Devabalaji KR and Jeas A 2017 An Levenberg–Marquardt trained feed-forward back-propagation based intelligent pitch angle controller for wind generation system *Renewable Energy Focus* **22** 24-32
- [12]. Sitharthan R, Sundarabalan CK, Devabalaji KR, Yuvaraj T and Mohamed Imran A 2019 Automated power management strategy for wind power generation system using pitch angle controller *Measurement and Control* **52(3-4)** 169-182
- [13]. Sundar DS, Umamaheswari C, Sridarshini T, Karthikeyan M, Sitharthan R, Raja AS and Carrasco MF 2019 Compact four-port circulator based on 2D photonic crystals with a 90° rotation of the light wave for photonic integrated circuits applications *Laser Physics* **29(6)** 066201
- [14]. Sitharthan R, Parthasarathy T, Sheeba Rani S and Ramya KC 2019. An improved radial basis function neural network control strategy-based maximum power point tracking controller for wind power generation system *Transactions of the Institute of Measurement and Control* **41(11)** 3158-3170
- [15]. Rajesh M and Gnanasekar JM 2017 Path observation based physical routing protocol for wireless ad hoc networks *Wireless Personal Communications* **97(1)** 1267-1289
- [16]. Palanisamy K, Varghese LJ, Raglend IJ and Kothari DP 2009. Comparison of intelligent techniques to solve economic load dispatch problem with line flow constraints *IEEE International Advance Computing Conference* 446-452
- [17]. Sitharthan R, Ponnusamy M, Karthikeyan M and Sundar DS 2019 Analysis on smart material suitable for autogenous microelectronic application *Materials Research Express* **6(10)** 105709

- [18]. Rajaram R, Palanisamy K, Ramasamy S and Ramanathan P 2014 Selective harmonic elimination in PWM inverter using fire fly and fireworks algorithm *International Journal of Innovative Research in Advanced Engineering* **1(8)** 55-62
- [19]. Sitharthan R, Swaminathan JN and Parthasarathy T 2018 March. Exploration of wind energy in India: A short review *IEEE National Power Engineering Conference* 1-5
- [20]. Karthikeyan M, Sitharthan R, Ali T and Roy B 2020 Compact multiband CPW fed monopole antenna with square ring and T-shaped strips *Microwave and Optical Technology Letters* **62(2)** 926-932
- [21]. Sundar D Sridarshini T, Sitharthan R, Madurakavi Karthikeyan, Sivanantha Raja A, and Marcos Flores Carrasco 2019 Performance investigation of 16/32-channel DWDM PON and long-reach PON systems using an ASE noise source *In Advances in Optoelectronic Technology and Industry Development: Proceedings of the 12th International Symposium on Photonics and Optoelectronics* 93
- [22]. Sitharthan R and Geethanjali M 2014 Wind Energy Utilization in India: A Review *Middle-East J. Sci. Res.* **22** 796–801 doi:10.5829/idosi.mejsr.2014.22.06.21944
- [23]. Sitharthan R and Geethanjali M 2014 ANFIS based wind speed sensor-less MPPT controller for variable speed wind energy conversion systems *Australian Journal of Basic and Applied Sciences* **8**14-23
- [24]. Jerin ARA, Kaliannan P, Subramaniam U and El Moursi MS 2018 Review on FRT solutions for improving transient stability in DFIG-WTs *IET Renewable Power Generation* **12(15)** 1786-1799
- [25]. Prabakaran N, Jerin ARA, Palanisamy K and Umashankar S 2017 Integration of single-phase reduced switch multilevel inverter topology for grid connected photovoltaic system *Energy Procedia* **138** 1177-1183
- [26]. Rameshkumar K, Indragandhi V, Palanisamy K and Arunkumari T 2017 Model predictive current control of single phase shunt active power filter *Energy Procedia* **117** 658-665
- [27]. Fathima AH and Palanisamy K 2016 Energy storage systems for energy management of renewables in distributed generation systems *Energy Management of Distributed Generation Systems* 157
- [28]. Rajesh M 2020 Streamlining Radio Network Organizing Enlargement Towards Microcellular Frameworks *Wireless Personal Communications* 1-13
- [29]. Subbiah B, Obaidat MS, Sriram S, Manoharn R and Chandrasekaran SK 2020 Selection of intermediate routes for secure data communication systems using graph theory application and grey wolf optimisation algorithm in MANETs *IET Networks* doi:10.1049/iet-net.2020.0051
- [30]. Singh RR and Chelliah TR 2017 Enforcement of cost-effective energy conservation on single-fed asynchronous machine using a novel switching strategy *Energy* **126** 179-191
- [31]. Amalorpavaraj RAJ, Palanisamy K, Umashankar S and Thirumoorthy AD 2016 Power quality improvement of grid connected wind farms through voltage restoration using dynamic voltage restorer *International Journal of Renewable Energy Research* **6(1)** 53-60
- [32]. Singh RR, Chelliah TR, Khare D and Ramesh US 2016 November. Energy saving strategy on electric propulsion system integrated with doubly fed asynchronous motors *IEEE Power India International Conference* 1-6
- [33]. Singh RR, Mohan H and Chelliah TR 2016 November. Performance of doubly fed machines influenced to electrical perturbation in pumped storage plant-a comparative electromechanical analysis *IEEE 7th India International Conference on Power Electronics* 1-6

- [34]. Sumithra M, Abraham A, Rajesh M and Nithiyandam N 2019 Mining social media content to predict peer trust level in social networks *International Journal of Engineering and Advanced Technology* **6S3** 1959-1964
- [35]. Venkatesh K, Ali MJS, Nithiyandam N and Rajesh M 2019 Challenges and Research Disputes and Tools in Big Data Analytics *International Journal of Engineering and Advanced Technology* **6S3** 1949-1952