HYDROPONICS CULTIVATION USING REAL TIME IOT MEASUREMENT SYSTEM

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Abstract. The concept hydroponic cultivation is performed in greenhouses or in various plant factories. This sort of cultivation is generally evaluated with pH and electrical conductivity. It may not provide complete information regarding any imbalance that is encountered in cultivation process. This causes poor yield or wastage of resources. Thus, to overcome these limitation IoT measurement system has to be implanted in this cultivation process, where sensors and actuators may measure the corresponding reading when need and given to man power. Therefore, imbalance in attaining nutrients is eliminated by constant monitoring of resources towards plant cultivation. This facilitates farmers to handle the nutrients issues that are encountered in cultivation. The performance measurement of the system developed was computed with feasibility of IoT system for automatic measurements. The outcomes of the systems are computed and validated for further processing. Some specific measures are considered where there is no specific relationship among standardized analysis. The sensitive responses have to be examined and analyzed.

Keywords. IoT, Hydroponic, management system, cultivation, indicators

1. Introduction
In this revolutionary world, healthier life can be achieved only when fresh and non-pesticides based foods has to be consumed [1]. Fruits and vegetables are considered to be healthy only when it should not be contaminated with chemicals and it should not harm body when provided to pesticides like over and so on [2]. In real world scenario, it is not concluded that a human is consuming a healthier food without any chemicals or pesticides in it. Various reports have stated that there is death due to the inclusion of pesticides over the plants [3]. Generally, people who died of pesticides are agricultural workers or farmers with an age group of 15-30 years old [4]. Indeed, conventional way of planting
also has some deficiency. Initial one is origin of diseases and pests [5]. Next, various forms of plants needs some land suitability for farming. Next, area of cultivation with soil source is directly influenced by amount of vegetables which is generated [6]. Next, fertilizers use and water are lesser effectual. Weaknesses are preliminary form of hydroponic development based farming method.

These are automated systems that may provide nutrients on timely basis for regulating hydroponic with growth rate of 50% which s faster than soil [7]. Nutrient solution based conductivity is based on boosting plant growth and using controllers for it. Conductivity measurement in system is a form of electrode [8]. Nutrients amount requires manual computation and it should be stored in processor. This will be compared with amount of nutrients and computed manually. If needed lesser, pumps may turn on automatically to assist nutrients to appropriate value [9]. Finest solutions are attained by managing conductivity and nutrient solution with pH. It plays an essential role in absorbing every element during planting. With nature cycle, plants are in need of source for photosynthesis, light needed for plant measure is light integral. It may shows various responses to diverse light spectrum. To model a growing chamber for plants, there is a necessity of nutrient solution, climate and light. OpenAg source has been launched to construct food computer, server for maintaining plants [10]. Here, construction of automation system for hydroponic is done with maintenance of pH and conductivity of nutrient solution, controlling light, environmental monitoring like humidity, temperature, CO\textsubscript{2}, pH and so on. To construct these sorts of systems that may functions with numerous processes. There are diverse of available RTOS, freeware and so on.

The remainder of the work is organized as: Section II is literature review, Section III is research methodology, section IV is numerical results and discussion. Section V is conclusion with future research directions.

2. Literature review
This section discusses about the background study that are related to hydroponic cultivation process. In [11] author reused nutrients for growing as a source of cost reduction and reducing environmental causes over hydroponic system. Electrical conductivity and pH values are monitored to compute status of nutrients provided to plant production. Author in [12], investigates the nutrient imbalance ratio and periodical adjustments that are introduced and appropriate intervals are considered. Use of periodical
variation is managed by various limitations. It may help farmers to react faster to various nutrient changes. Author in [13], used analyzers to compute concentrations of ions over hydroponic solutions. However, this may need appropriate immersion and determination of nutrients in stronger signal drift and diminished sensitivity [14]. Computer based assessments may perform automatic solution and electrode calibrations, maintenance and sampling. It may enhance nutrient concentration based measurements [15]. An automated sensing system for nutrients has to be calibrated periodically and should provide sample solutions.

3. Proposed Methodology
The proposed model is constructed based on the testing scenario. Moreover, certain data acquisition and sub-systems are involved in modelling of system by facilitating data collection, normalization, handling liquid level, electrode measures based on test sequences. The pre-processing is used to collect analog signals from circuit board and buffer the impedance rate. Normalization rates are automatically transferred to sample holder for test solutions. Speed of motor will be managed by motor fixed with the design model. The speed will be determined with operation held with preliminary identifications. The system works effectively with rinsing, stirring and draining functions. To manage the system normalization, two point normalizations is carried out and a program was developed. User interface is utilized to configure pump time operation, rotational speed and measurement time for holders.

Program facilitated by sample monitoring operations for every five days and ion concentrations are measured for all systems over UI screen. So as to validate predictive capability of proposed system, this system has to be installed in farming land. To offer various concentration levels in cultivation of fruits and total samples of hydroponic solutions are chosen from diverse locations in greenhouses that may comprises of nutrient solution, slabs, drainage, mixing tank. When system conduct sampling operation and sub-sample monitoring were taken manually and transmitted to standard testing laboratory to provide appropriate concentrations of standardization methods. The concentrations are computed with monitoring system when compared to standard instruments to validate performance of proposed system with regression analysis.

The application test environment was performed over Indian farming land located in Tamil Nadu. Hydroponic solutions are done with various nutrients that may have significant ingredients of commercial fertilizers with similar procedures. The concentration of the ions is considered respectively. Hydroponic solutions are adjusted and initial volume for irrigation is based on cumulative radiation approaches. This procedure is used by various studies. Drainage solution will be returned to drainage tank that has to be measured. Water, drainage, water are pumped to tank till water level reaches the initial level. Water volume was supplied to maintain pH level. Hydroponic solution of pH was altered manually with a range of 6.5 hydroponic solutions. This system may monitor the drainage for five times every data. The solution will be monitored without any treatments. Next, it will be replaced by newer solutions and various system responses to change ionic concentrations in hydroponic solutions. Salt level will be monitored to change electrode response caused by reduction in ionic concentrations. At last, salts were replaced with newer solution and salts replenishment was observed. There will be no modifications in total nutrients salts obtained from solutions. Constant validation test, sub-samples of hydroponics are considered for various days during cultivation process. This process is done to provide actual concentration of ions in samples.

The system may show a stronger relationship with ion results and root mean square error. K-Concentrations are over estimated slightly with slope of 1.18 and R² of 0.98 is regression equation. Estimation over normal concentration which are accessible in hydroponic solutions are nearer to 1:1. As well, results may show linear relationship with R² of 0.98 that K measurements would be more feasible. Regression may show underestimation with slope f 0.76. Ca concentration is deviated from normal Ca concentration and relatively higher RMSE of 42 mgL⁻¹ was attained. Lower estimated are attained with Ca is owing to differences in ions among normalization solutions. This may affect sensitivity solution. This normalization solution with background ions provides solutions to
hydroponic solutions. Higher linear relationship among these concentrations may provide Ca in computing hydroponic solutions. The following results are validated, where calibration factors are utilized to adjust Ca measurements with variations in ICO and ISE estimations in application analysis.

4. Results and discussions
This section explains the numerical results and discussion of proposed model. The simulation was done with MATLAB simulation environment. The comparison of various concentrations is done in this section which is discussed in section given below. The modelling of IoT based monitoring system may be monitored resourcefully in concentration with Ca, NO₃, and K in hydroponic solutions with appropriate level of sensitivity. However, system may be reacted with changes in ion concentration by reacting to treatments, salts and replenishment. The outcomes may demonstrate the system is more feasible for IoT based monitoring of diverse concentrations of K, Ca and NO₃ in hydroponic solutions. Table I depicts the system specifications of proposed models.

| Systems | Components       | Specifications          |
|---------|------------------|-------------------------|
| Sensor array | sensors     | ISE                     |
| Sample holder | Holder     | Rotary disk             |
| Pumps    | Peristaltic     | 12 V, 60 ml min⁻¹       |
| Normalization | Water tank | 5 L                     |
| Drainage solutions | Tank     | 6 L                     |
| Data acquisition | PC        | CPU, OS                 |
| Amplifier | Power supply, controller and signal conditioning board | DC input, DC output, AC input, AC output |
Fig 2. RMSE computation

Fig 3. Average RMSE computation

Fig 4. Ca concentration based RMSE computation
Fig 2, Fig 3, Fig 4 shows the RMSE computation of various compositions used in proposed model. Fig 5 shows concentration computation of proposed model. This system is validated with hydroponic solutions to measure the above three concentrations. The linear relationship between them has been analyzed. The proposed model is considered to be more feasible. This can be implemented in various cultivation processes. The tested results are satisfactory and capability of this system is more effectual. In future, this system is implemented with various concentrations at various stages of crop cultivation.

5. Conclusion

This investigation concentrates on hydroponic cultivation in which crops are grown without the soil usage. However, nutrients from soil are provided directly to various water reservoirs. Nutrients that are needed for plants are added by proper measurements. Here, plants may attain essential nutrients from water as equal to that of soil. With the adverse growth of IoT and its characteristics this process is turned to be automated. Data that are gathered from this approach is processed and given to cloud for storage purpose. Also, mobile applications plays crucial role in this process. The growth of plants is monitored constantly from the sensors used in hydroponic system. Thus, this system can be used under any environmental conditions and operated through applications.

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Fig 5. Three concentrations analysis
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