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Automated Water Condition Monitoring for Grass-Swale Drainage System

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Abstract: In the 'Internet of Things' (IoT) based drainage monitoring, data collection, and information analysis through various sensors will play an important role in the future, and it will be a core technology to develop IoT-based drainage monitoring systems. This project focused on the Monitoring Grass Swale-Drainage System using Arduino based on the IoT module in the Irrigation and Drainage industry. One of the conventional methods used by researchers is to instruct technical staff to visit the drainage at the appointed time and perform manual tests in the laboratory to analyze the quality of the irrigation system. Because of this, it requires a lot of time and effort. Therefore, this project emphasizes the wireless IoT module system to collect information from various sensors to monitor the drainage via the internet. The project was developed using an Arduino microcontroller, 'Wi-fi Ethernet Shield', multiple sensors such as ultrasonic, rain detector, and flowrate sensor. Parameter value readings which are water level and total flow discharge velocity will be sent from the Arduino subsystem to the 'Wi-fi Ethernet Shield' module and then displayed on the Android smartphone apps. Next, the information sent to the IoT platform ThingSpeak can also be reviewed by researchers such as hydraulic parameters or weather conditions. The project proposes a monitoring system that emphasizes aspects such as low cost, fast and real-time data acquisition, easy installation, and easy operation.

Keywords: Grass Swale, Swale Profile, Flow Velocity, Flow Discharge

1. Introduction

The drainage system is an infrastructure system that is so important, especially in urban areas. Planning the construction of a systematic drainage system must be designed properly and well-functioning to reduce the risk of flooding and water pollution [1]. Water quality and quantity observation is the toughest implementation of impure water effectively. To ensure the drainage system able to overcome the flooding

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problem and filtering issues, a new approach has been projected. Grass swale as shown in Figure 1 is one of the drainage designs that can filter the runoff or storm water before flowing to the main drain and river [2].

Figure 1: Wet grassed swale site

The Internet of things (IoT) method is a new approach for wireless communication technologies to be monitored in a real-time event in this industrial revolution (IR4.0) era [3]. Wireless technologies are increasing for aiding human's personal and daily tasks effectively. The needs of a systematic data collection module for monitoring the flow velocity and discharge of the water through the swale is the main issues to be focused and can be integrated with an IoT approach. With the increase of the wireless device network technology in the internet of things, real-time observation can be done through the system. This proposed system is valuable as researchers are capable to get information more flexible. Hence, the aim of this automatic data acquisition system can help to overcome these challenges and assist the researchers to collect the data and able to analyze it conveniently for monitoring the water system.

2. Materials and Methods

Data collection was conducted at wet grassed swale site in Universiti Tun Hussein Onn Malaysia (UTHM) campus, which collected before and after the rainfall event. The equipment used to collect the data is shown in Figure 2, and the uses of equipment are as follows:

- YF-S201 Hall Effect Water Flow Meter / Sensor – measures the energy of moving water in the swale and translates it into a flow velocity [4].
- Ultrasonic Sensor HC-SR04– measures the cross section of swale in order to develop the swale profiles.
- Raindrop detector – notify weather status
- Measuring tape – measures the width and depth of surface drainage [5].

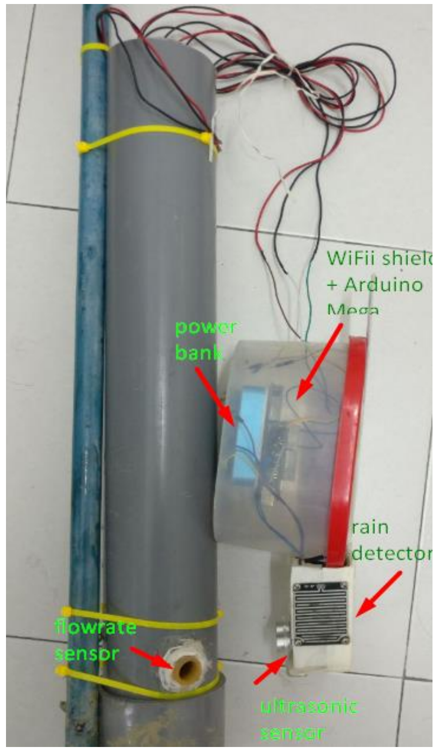

Figure 2: Final prototype

The width length of swale is estimated 5 Feet and divided into each section. The distance from each Section A is increasing by 1 Feet. Figure 3 shows the procedure development of swale and prototype implementation. The data obtained from the swale are:

- Flow depth of the swale, T
- Flow discharge of the swale, Q

According to Figure 3, the development of the case needs to be done perfectly to ensure the placement of the sensor not causing the error or faulty. In order to ensure the volume of water only passing through the holes at the flowrate sensor, the case needs to be waterproof so that there will no water leaks into the case as to maintain the functioning of the sensor.

2.1 System design

The primary tool to construct the development of this project is the Arduino IDE software package. This project is divided into two phases. In the first phase, the development of the subsystem includes all input sensor modules for the monitoring system. The next stage is the hardware development of IoT Wi-Fi shield and using Thing speak web platform database. The device can collect the data of the monitoring system as long as there is an internet connection. Figure 4 shows the illustration of the system architecture for this project development whereas the block diagram of this system can be seen in Figure 5.

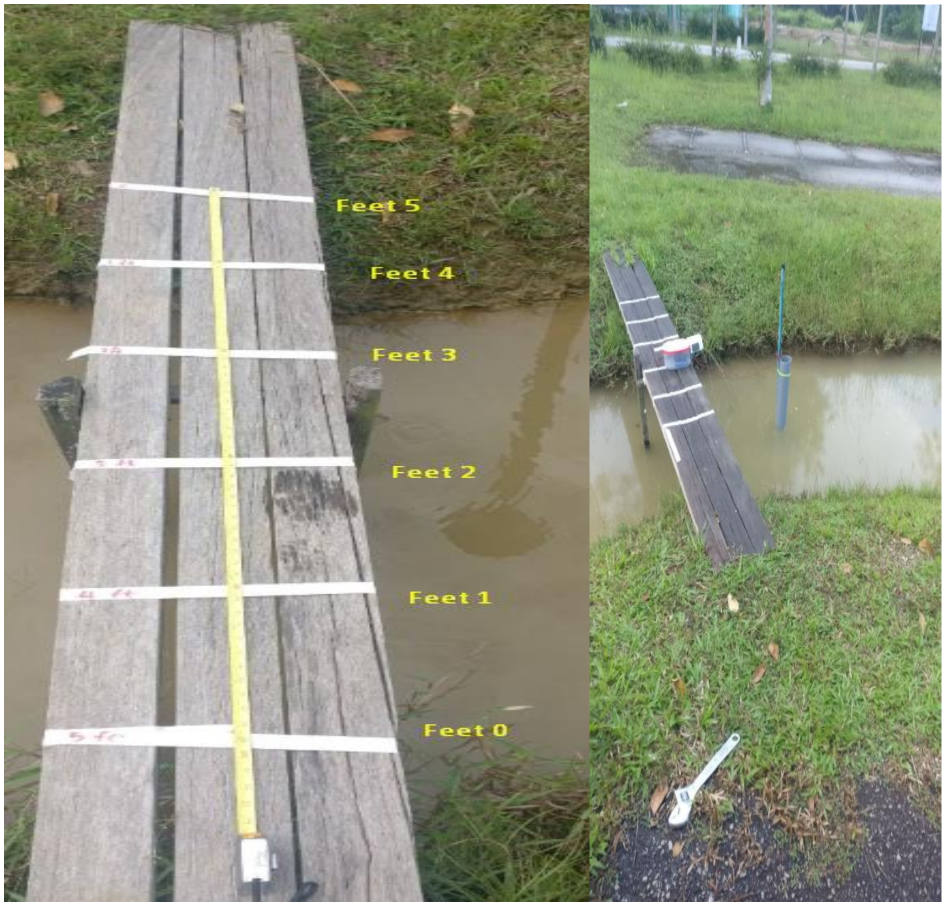

Figure 3: site work procedure with implementation of prototype

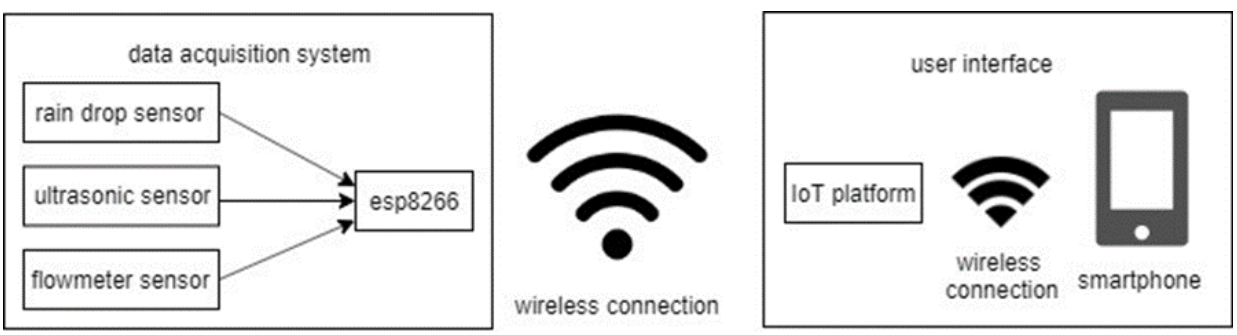

Figure 4: Overview of system architecture

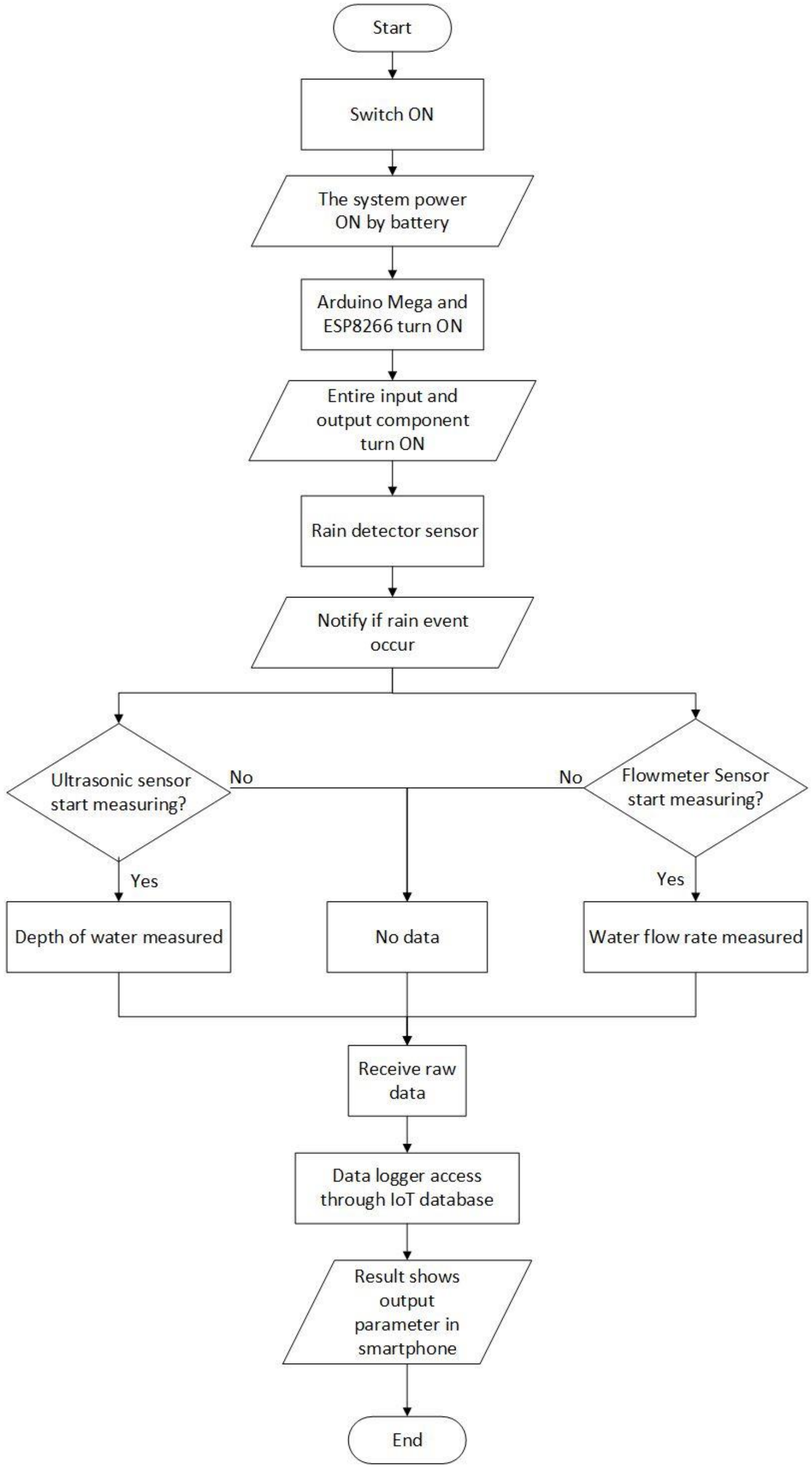

Figure 5: System flowchart for grass-swale water monitoring

3. Results and Discussion

The result of this project is shown in Figure 6 until Figure 9, where the design of the GUI is simple and neat for the user.

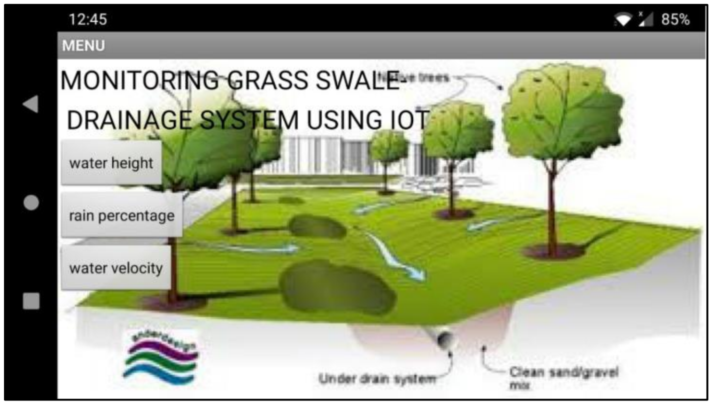

Figure 6: Main menu

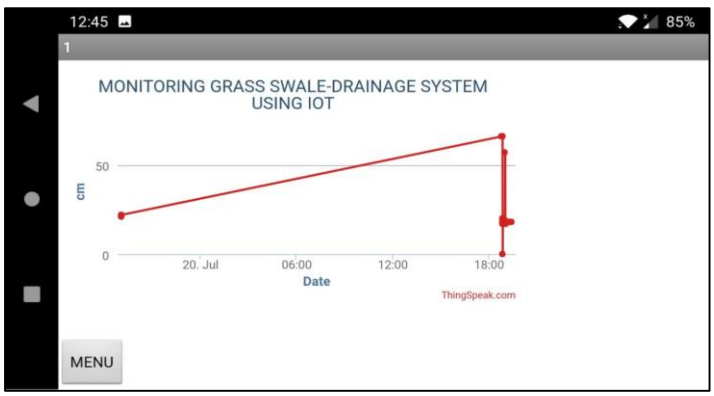

Figure 7: Option for water distance

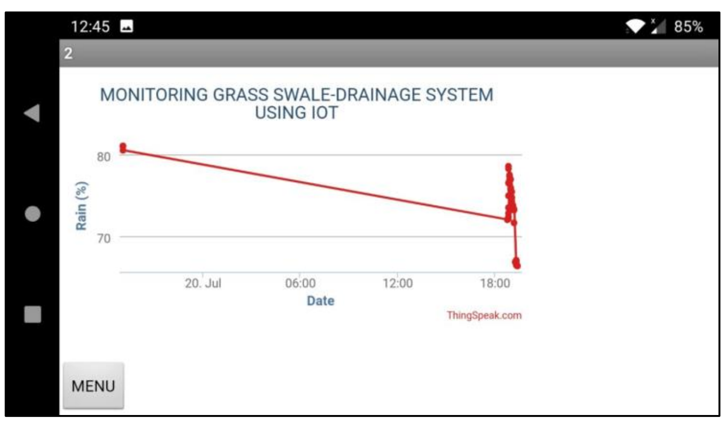

Figure 8: Option for rain percentage

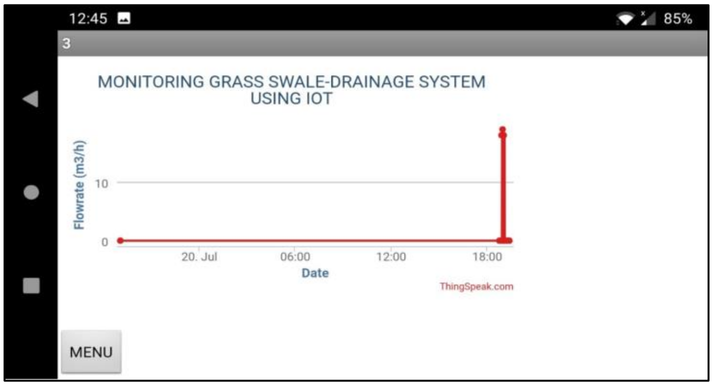

Figure 9: Option for water flowrate

Table 1 shows the flow depth at 5 section points divided based on the proposed method. Each point (feet) is representing the width length of the water stream. Point 2 and point 3 had been selected as the center position of the drainage. Based on the result, the deepest depth is at the range center point (feet) 3, and this can be seen from the data retrieved on 20 July 2020, where the water level reading is at 0.024-meter depth.

Table 1: Water depth reading

Point (feet)	Date	Measure water height by sensor (m)	Measure water height by sensor (m)	Distance from the sensor to water surface (m)
1	19/07/2020	0.016	0.016	0.70
	20/07/2020	0.016	0.017	
2	19/07/2020	0.02	0.019	0.71
	20/07/2020	0.02	0.021	
3	19/07/2020	0.02	0.024	0.76
	20/07/2020	0.03	0.025	
4	19/07/2020	0.02	0.0219	0.75
	20/07/2020	0.02	0.02	
5	19/07/2020	0.01	0.0087	0.65
	20/07/2020	0.01	0.09	

Table 2, at point (feet) 2 and there is no rain condition produced the highest value of flow discharge, which is 0.00583333 m^3/s. Meanwhile on point (feet) 3 the data has produced varies values during the 10 minutes period. The data collected after raining fall event at a worksite and thus may contribute to the changes of the measurement readings throughout the process of data collection for a specific point. The highest value of flow discharge is 0.00527778 m^3/s at time 19:01 on 20 July 2020 where the other pulse may only give 0.005 m^3/s at time 19:03 and 19:05 on the same date.

Table 2: Result of flow discharge

Point (feet)	Date and time	Rain	Flow discharge, Q (m^3/s)	Water level (m)
2	19/07/2020; 18:57	No	0.00583333	0.019
3	20/07/2020; 19:01	Yes	0.00527778	0.025
3	20/07/2020; 19:03	Yes	0.005	0.025
3	20/07/2020; 19:05	Yes	0.005	0.025

From this analysis, it is shown that rain factor condition may contribute to the drainage flow discharge instead of another factor such cross-sectional area. This is because when the cross-sectional area has the highest value of flow velocity thus increased the flow discharge. Nevertheless, it does not mean if the largest cross-sectional area will decrease the flow velocity and flow discharge of the swale. This may be due to several factors such as the swale profile, the hydraulic parameters, the distance between a section of the swale, and the type of vegetation that grew at each section of the swale.

4. Conclusion

In conclusion, the idea of this project is achieving the target were to approach a new measurement and monitoring method by using automated sensor and IoT. Several phases had been planned to make sure the system operated accordingly. Besides that, with the collected data, the analysis may be instant for certain configuration happen at the site thus it will notify the researchers immediately. Additional sensors may come optional and helpful to handle this water monitoring drainage system in the future. As mention earlier, water quality is another factor to be concerned instead of the quantity of water at the grass swale- drainage systems. Many items may suit depends on the fundamental requirements of this study the quality of the water such as sensor pH, turbidity sensor, humidity sensor and many more. As for other recommendations, casing design to put into the drainage water need to be considered when designing a platform to place the flowrate sensor. This water velocity parameter could have disturbance when to take the reading if the physical hardware induces the rate of obstacles to the water stream speed.

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