Monitoring the Speed of Water Flow by using Water Flow Sensor System Cooperate with Wireless Transmission

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***Abstract*-An unnamed autonomous vehicle, which called UGV, USV or AGV, is essentially an autonomous robot that operates without the need for a human controller on the basis of artificial intelligence technologies. Recently, unmanned autonomous vehicle is a popular topic. Predominantly these vehicles are used to replace humans in hazardous situations, such as handling explosives and in bomb disabling vehicles, where additional strength or smaller size is needed, or where humans cannot easily go. They are also used in industries such as agriculture, mining and construction [1].**

A complete unmanned autonomous vehicle loads a lot of different sensor systems which are IMU system, GPS system, and Radar system…etc. With these sensors, the vehicle can collect huge and complete data which engineers need. At the same time, this information can improve its performance to be smarter.

In this paper, I designed a water flow sensor system which can monitor the speed of the water flow and filter more than 70% of the noise by low pass filter. Considering the vehicle is hard to lading a computer when it is working, I used the Xbee to be a device which can transfer data by the wireless. Therefore, we can obtain the real-time data and analysis them immediately. After computer receiving the data from the Xbee, the system can plot the real-time figure by programming in Python.

I. INTRODUCTION

With the advancement of technology, the technology of unmanned vehicles is becoming more and more mature. According to different unmanned vehicles for different purposes, engineers will configure different systems to load on the vehicle. For example, if we want a vehicle can automatic cruise in a certain area, it definitely needs a GPS system. We need to design a Radar system, if we want this vehicle can detect the surrounding environment. However, I figure out that a vehicle cannot determine its velocity if it just loaded a GPS system. In order to achieve this purpose, I designed a water flow sensor system (as the Figure 1.) to monitor the speed of the vehicle. The components of this system are microcontroller, flow sensor, Xbee, and circuit board.

In this project, I choose the Arduino micro pro to be my microcontroller. The biggest advantage of Arduino micro pro is that it is not only very small but also has high performance of the calculation ability which compare which same size of others microcontrollers. It does not take up too much space, so vehicle loads more system. The other reason I choose it is that Arduino is an open-source internet-based platform that combines both software and hardware which means that it can help users build projects without difficulties.

For the flow sensor, I choose YF-S201(as Figure 2). This type of flow sensor is used to measure liquid flow within a pipe and is ideally suited for monitoring water consumption in irrigation control systems [2]. Inside the housing, a small pinwheel with an attached magnet is spun by passing water; as the magnet makes each revolution, a hall effect sensor inside the housing outputs a pulse on the yellow wire [2]. The sensor is best suited to flow rates from 1 to 30 liters per minute; therefore, this flow sensor is suitable for my requirement in this system.

In order to achieve wireless transmission, Xbee is a good choice for this project. Arduino platform and XBee radio modules from the DIGI Company [3]; therefore, they have perfect capacity between each other. Xbee supports IEEE 802.15.4 or ZigBee communication protocol. ZigBee supports point-to-point, point-to-multipoint, star, and mesh architectures. Each network device is called a "node." Based on these attributes, Xbee can easily and effectively transfer the data from the system to computer in its effective coverage. Figure 3 details the main features of Xbee modules S1.

In the computer side, I obtain the serial data from the Xbee by programming in Python. Because it will be easier to integrate or cooperate with other

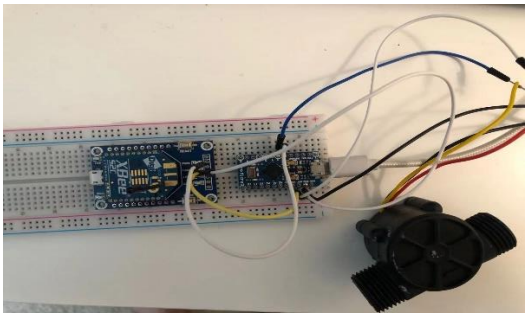

Figure 1. Water flow sensor system

Figure 2. Flow sensor YF-S201

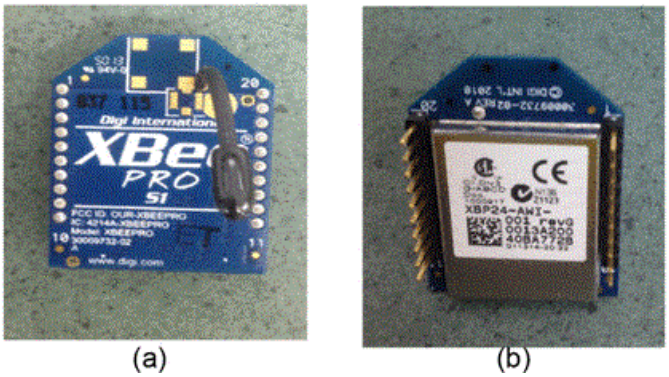

Figure 3. Tested radio modules: (a) front and (b) rear side of the XBee module S1 Pro [3]

sensor system in the future. There are any factors such as undercurrent, reflection wave, or obstacle under the water will affect the sensor to collect the data. In order to avoid these errors or affections, I designed a low pass filter to filter the noise.

II. SYSTEM DESIGN

The purpose of this system is that monitor the speed of the water flow. My input is the value of water flow. Then, transfer the information to my computer by using Xbee. And the power source is power bank. Figure 4 is the flow chart of transfer data.

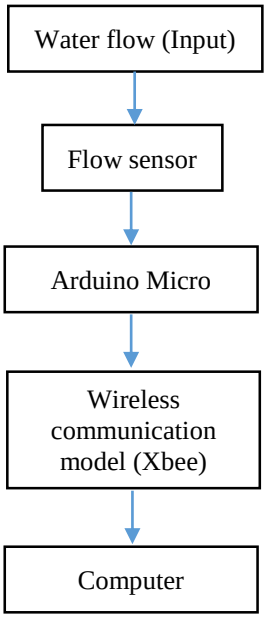

Figure 4. Flow chart of transfer data

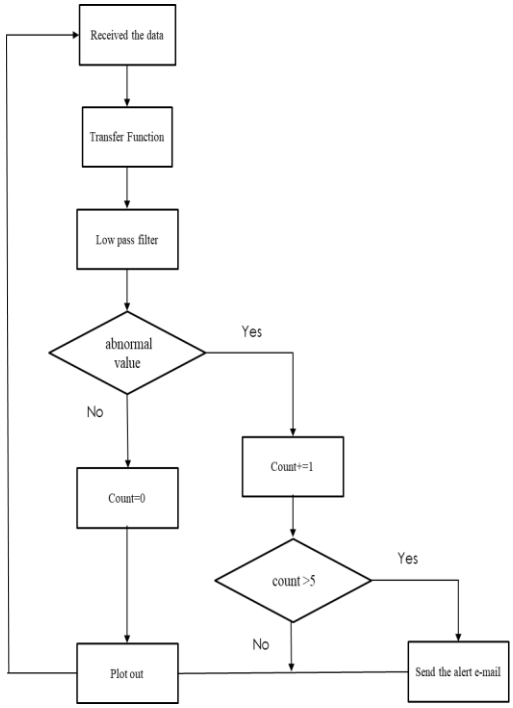

Figure 5. The flow chart of after computer received the data

The computer received the input which is value of the water flow form the Xbee; however, the result we perused is the speed of the water flow. I programmed the transfer function and the low pass filter by Python. After the filtering, the system will plot the result in real-time. To prevent unexpected results, I designed a function which can send alert notification e-mail to the user's mail box when the sensor detects abnormal value for five seconds. Figure 5 shows the flow chart of after computer received the data.

III. METHDOLOGY

In this system, I used the Arduino library as following:

```
#include <SoftwareSerial.h>
#include <Printers.h>
#include <XBee.h>
```

The pin 2 and pin 3 of the Arduino micro pro are the pins which can received the serial data. Therefore, I choose pin 3 to received my input and I set baud rate for 9600. The flow sensor outputs a pulse on the yellow wire. Each pulse output represents approximately 2.25mL of fluid. I used ***interrupts()*** function to ensure the system can receive every pulse from the sensor. Then, I used ***xbee.print()*** function to transfer data.

In the computer side, I used the Python library as following:

import serial as sr
import matplotlib.pyplot as plt
import smtplib

The first thing when we receive the data is that transfer unit of the data from liters per minute to meters per minute. The transfer function is water flow divide by cross-sectional area of water pipe:

$$\frac{The\ value\ of\ water\ flow}{1.1304\ \ cm^2}$$

After get the speed of the water value, I put it in to the low pass filter which is a filter that passes signals with a frequency lower than a selected cutoff frequency and attenuates signals with frequencies higher than the cutoff frequency. The low pass filter function is following:

$$V_n = \alpha V_{n-1} + (1-\alpha)v_n$$

Where,

$$\alpha = \frac{T_f}{T_f + T_s}$$

Considering the low pass filter will derive the delay for the system. Higher filter ability has higher delay, and vice versa. I need to find the balance between filter ability and delay. After few of times experiments, I choose parameter equals to 0.78.

I use two figures to show the result. One is the water flow value before and after the filter, and the other one shows speed of the surf-board vehicle. Both of these figures are real-time plot out the value. The plot function is following:

plt.figure()
plt.title()
plt.xlabel()
plt.ylabel()
plt.plot()

One of the purpose of this system is that it can work 24/7 and without a person always looking at the screen. Therefore, engineers need to be notified when some error our unexpected results happened. For this project, I set the unexpected value is higher than 40 meters per minute and it occurs lasts for five seconds. If the system received the unexpected value once, the value of count will plus one and it will equal to zero if next value is not higher than 40. When count equals to five, the system will send an alert e-mail to user's mail box by function:

smtpObj.sendmail(sender, receivers, message)

IV. RESULT

I use the faucet to simulate the environment of surf-board vehicle working on the water surface. Control the flow of the faucet to simulate underwater conditions. Figure 4 and Figure 5 show the experiments results.

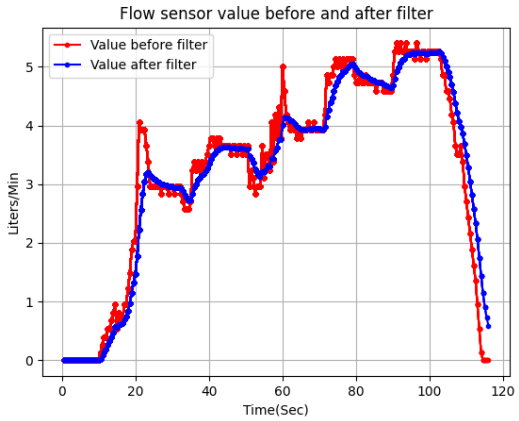

Figure 4. Flow sensor value before and after the filter

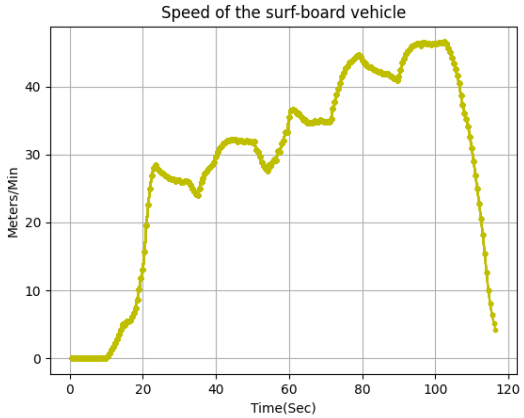

Figure 5. Speed of the surf-board vehicle

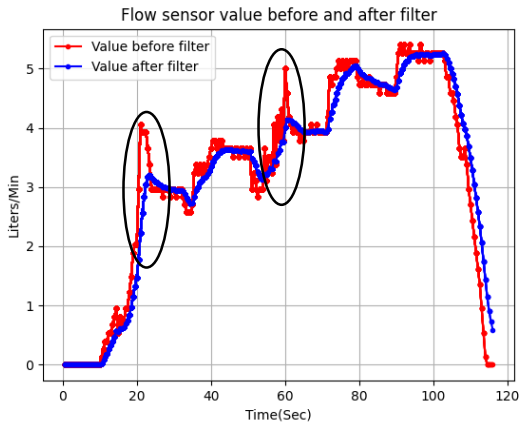

Figure 6. The external force happening

In the Figure 6, there are two circle areas show some external force happened immediately.

Through the external force happening, we can observe the performance of the low pass filter. And we can see that when the external force happened, the result of value after filter does not have too much influence. And the delay controls in about two seconds.

V. SUMMARY AND FUTURE WORK

In this project, the water flow sensor system I designed not only can transfer data remotely bit also can send the alert e-mail when the unexpected value occurred. The low pass filter has a good performance when sensor received an external force influence. However, the experiment environment is not in real water areas such as pond or ocean. There may have other situation or parameters need to be concerned. The distance I tested for the wireless is about ten meters without any obstacle. When this system applies on the vehicle in the future, I need to test what is the maximum distance for Xbee.

For the future work, I can load two water flow sensor systems on the vehicle's right and left side. Therefore, the turning angle of the vehicle is observable. We can more accurately grasp the movement of the vehicle. Because when the vehicle turns right, the left sensor's speed will higher than left, vice versa. The other application in the future is that we can through this system to observe the undercurrent in the ocean. Many people like to go a beach to enjoy their summer vacation. However, undercurrent is a serious issue. With a serf-board vehicle which loaded this system. We can real-time monitor underwater condition and respond in a timely manner.

VI. REFERENCE

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[3] P.-E. G. C.-O. J. R.-C. E. B.-A. L. G.-M. F. Cama-Pinto A, "Received strength signal intensity performance analysis in wireless sensor network using Arduino platform and XBee wireless modules," *International Journal of Distributed Sensor Networks.*, July 2017.