International Journal of Environmental Engineering– IJEE
Volume 1 : Issue 4 [ISSN 2374-1724]
Publication Date : 27 December,2014

GSM and GPS Based Autonomous in Situ Water Pollution Monitoring System

[Ying Liu[1], Jing Wang[2] and Shamsul Masum[1]]

Abstract— River water pollution monitoring is becoming an increasingly important task for environment agencies. The challenging is that very large area needs to be surveyed event for a relatively small section of the river. Furthermore, dynamic changes of the environment condition require real time sampling of the parameters. Unmanned monitoring station network has limited resolution. Deployment of water quality monitoring vessel is extremely expensive. We have developed a practical solution that uses networked agents to achieve near real-time river pollution monitoring. The agents are autonomous/passive in situ measurement floats that can be deployed from the upper stream of the river. The ideal is that when the floats travel down stream the river, the sensors on board will sample and analyze the physical and chemical parameters. The GPS position and the data from the sensors will be uploaded to the base via GSM network. The trajectory of the floats and parameter changes can therefore be dynamically updated using Google map graphical overlay This paper presents the design, implementation and testing of the system.

Keywords—— ***Wireless, in situ measurement, mobile monitoring, environment monitoring, drifter***

I. Introduction

With the fast industrialization over the last thirty years, the pressure on water resources is increasing rapidly. This is particularly the case in China, home to almost 20% of the world's population. Safeguarding and managing this precious resource is one of the top priorities of the government and environment agencies indeed.

As one of the major rivers running across the country west to east, Yangtze River is becoming increasingly polluted, according to an official Chinese government report. The pollution level has raised concerns about the potential health risks.

1 School of Engineering
University of Portsmouth
Portsmouth
United Kingdom

2 Chongqing |Collage of Electronics
Chongqing, China

The causes of the pollution are largely due to pig farming, fish farming, sewage discharge and worst of all industrial waste dumping.

The Chinese government, in recent years, has made considerable effort to widen the crackdown to go after the polluters, inspecting more and more factories on the river and stopping production at many sites. The crackdown and enforcement on the polluters however relies on timely and reliable evidence. Site inspection, an undertaking with conventional discrete sampling and laboratory analysis is neither effective nor practical. Monitoring vessels deployed by environment agencies surveying the river are limited because of the costs.

Passive float (drifter) with in-situ sensors offers great potentials in comparison with traditional sampling because process information can be gathered in a short time at low cost. In addition, sources of error are avoided, for example selective sampling or disturbing chemical changes during transport. The timely report of any possible water pollution will allow the environment agency to send the inspection team for further investigation if necessary. There have been numerous report of development and commercially available drifters with multiple sensors (ie WOCE SVP Surface Lagrangian drifters, SVP-B drifters). Most of the drifters available are primarily intended for ocean survey purpose. They have been used for tracking upper ocean water circulation and sea surface temperature. The drifters are increasingly being used to measure biogeochemical parameters within the ocean in recent years. These drifters are sophisticated instruments integrated with sensors and mobile radio communication devices. They are tracked by GPS and recoverable. The drifters may survive a few years from deployment.

The is no commercially available system which is suitable for river water pollution monitoring. We are developing in situ monitoring system, a micro drifter that can be released into the upper stream of the river. The drifter will be carried by the current traveling down the river. The drifter will be recovered after it reaches to its destination.

The drifter will collect data using its in situ senors. The drifter will transmit data to the base using the cellular phone network. As the sensors are carried by the water, their GPS receivers keep track of their movement. This also provides a snapshot of the direction and speed of the water at a point. This paper present the design and development of the micro drifter.

II. Drifter Design

The micro drifter will operate in a quite different environment compared to that of the drifters for ocean survey. The micro drifter operates in a more closed, shallow water. It will have more hazards natural or man made than that of its counterparts operated in ocean. For examples, the micro drifter will be more likely to be damaged by rocks at the riverbank, ships traveling along the water way. It is also more likely to be intercepted by people intentionally or unintentionally. The recover of the survival drifters can not be guaranteed. The main design criteria used in the development is therefore the costs. In our design, we have used the very low cost design and components. The drifter is considered as disposable. Once the drifter is release into the water, it is considered as write off.

The drifter consists of fiber glass reinforced drifter housing and electronics (including sensors, GPS, GSM modem, micro controller and batteries).

A. *Electronics Hardware*

Figure 1 shows the functional block diagram of the electronic unit of the micro drifter.

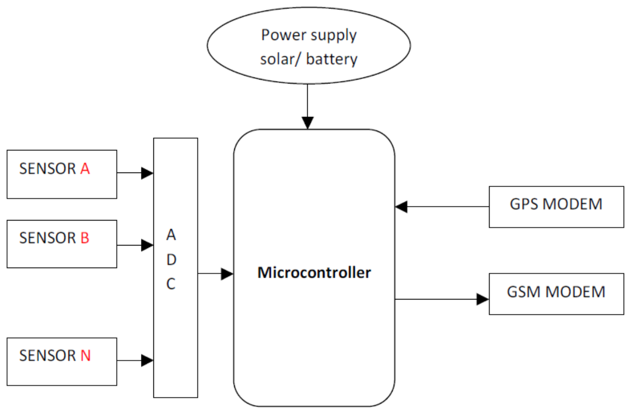

Figure 1

The design is based around the XA-G49 16-bit microcontroller which has an eXtended Architecture of 80C51 XA family. The processor features a 30 MHz clock at 5V, 64K Flash, 2K SRAM and 32 I/O lines. There are 2 UARTs available allowing easy interface to the GSM modem and GPS module. The processor is not the most powerful, but just good enough for the job. The processor is of extremely low cost.

Multiple sensors are used to collect the data (i.e. water PH level, oxygen content, temperature). The signals from the sensors are converted into digital data by multi-channel ADC and log into the flash memory on board.

In addition, data from sensors will also be passed to a Wavecom GSM-GPRS modem connected to the micro controller via RS232 interface. The Wavecom GSM-GPRS modem provides a highly extendable platform for the creation of a wide range of wireless telemetry solutions, supporting quad-band GSM/GPRS and EDGE, They are designed for external retrofits to existing non-wireless applications, or as a platform to develop new wireless products.

In order track the drifter and to generate the trajectory of the drifter, A Garmin GPS 18 LVC module it integrated. Garmin GPS 18 LVC has receiver and an antenna on it. Garmin GPS 18 LVC has the ability to track up to 12 satellites with first time-to-first-fix facilities. It also provides lower power consumption. Garmin GPS 18 LVC is waterproof and applicable for tough operating condition. It requires power to turn it on and also required a clear view of the GPS satellite for good performance. Internal FLASH memory which is inserted on GPS allows saving important data. The GPS modem outputs NMEA (Nation Marine Electronics Association) messages that are parsed for the needed information. In this development work, only UTC time, Latitude, and Longitude are stored. The data stream captured from the Garmin GPS 18 LVC module is shown in Figure 2.

The micro controller receives data from sensors and GPS modem which provide water quality information and location of samples. The micro controller will then transmit the data to the base via the GSM modem.

B. *Software*

The software development is based on XA-G49 development system board. Raisonance IDE (RIDE) is used for compiling or writing C codes which is supported by XA-G49 micro controller. Flash magic is used to upload the code on to XA-G49 micro controller. Visual studio is used to program C# Language. HyperTerminal and Terminal will be used for checking the communication status of the hardware with the help of AT commands. AT commands is set of instruction for communicating with GSM modem.

```
$PGRMM,WGS 84*06
$GPRMC,151646,A,5046.9795,N,00040.7381,W,000.0,130.0,070313,002.6,W*7B
$GPGGA,151646,5046.9795,N,00040.7381,W,1,05,2.3,1.0,M,47.8,M,,*53
$GPGSA,A,3,,05,,08,09,,,,,26,28,,3.6,2.3,2.3*3D
$GPGSV,3,1,12,03,00,009,00,05,52,195,40,07,16,058,00,08,47,057,37*79
$GPGSV,3,2,12,09,52,237,35,10,09,158,00,19,05,030,00,21,15,312,00*78
$GPGSV,3,3,12,24,05,239,00,26,80,318,44,28,47,115,39,36,00,000,00*74
$PGRME,11.3,M,23.4,M,26.2,M*1E
$PGRMT,GPS 18LVC - software ver. 2.80,P,P,R,R,P,,21,R*3C
$GPGLL,5046.9795,N,00040.7381,W,151646,A*35
$GPVTG,130,T,133,M,000.0,N,0000.0,K*7D
$PGRMV,0.0,0.0,0.0*5C
$PGRMF,706,400619,070313,151646,13,5046.9795,N,00040.7381,W,A,2,0,130,4,2*0E
$PGRMB,,,,,,K,,,*2D
$PGRMM,WGS 84*06
$GPRMC,151648,A,5046.9794,N,00040.7381,W,000.0,130.0,070313,002.6,W*74
$GPGGA,151648,5046.9794,N,00040.7381,W,1,05,2.3,-0.1,M,47.8,M,,*71
$GPGSA,A,3,,05,,08,09,,,,,26,28,,2.7,2.3,1.0*3D
$GPGSV,3,1,12,03,00,009,00,05,52,195,40,07,16,058,00,08,47,057,37*79
$GPGSV,3,2,12,09,52,237,35,10,09,158,00,19,05,030,00,21,15,312,00*78
$GPGSV,3,3,12,24,05,239,00,26,80,318,44,28,47,115,39,36,00,000,00*74
$PGRME,11.3,M,23.4,M,26.2,M*1E
$GPGLL,5046.9794,N,00040.7381,W,151648,A*3A
$GPVTG,130,T,133,M,000.0,N,0000.0,K*_
```


Figure 2 GPS Receiver Data Capture

The software consists of four operational modules that control the operation of the micro drifter prototype.

1) Sample data from sensors
2) Capture the GPS stream and filter the data
3) Initial the GSM modem and send data to base using AT commands
4) System control and power management

The software flow chart is shown in Figure 3.

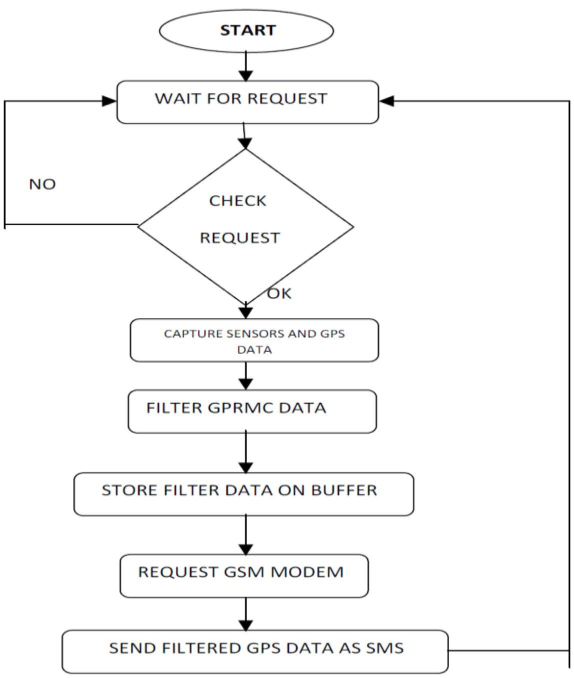

Figure 3 Software Flow Chart

As the prototype is powered by a 12V 2.3Ah battery pack and the drifter is potentially be operated for up to 4 weeks (from Chongqing to Shanghai), it is impotent to operate the power drain devices only when it is needed. The sensors, the analogue front end and the micro controller are all low power devices. The GPS module and the GSM modem draw up to 200mA in transmission mode. The drifter samples the data every 30 seconds. The data for 20 minutes (40 samples) will be stored in the micro controller flash buffer. The GPS and the modem are in sleeping mode during the 20 minute data collection period. They are waken up for 2 minutes before data transmission allowing the GPS module to capture the GPS position and the modem to establish the handshake with the mobile network reliably. The data is then send to modem transmission buffer as SMS.

III. Results

The micro drifter is still in its laboratory development stage. The prototype has been build. The preliminary tests have demonstrated that the framework of the prototype works fine. The development is still on going and we expect the fully working models later this year.

References

[1] Ahuja, S., (2013). Monitoring Water Quality: Pollution Assessment, Analysis, and Remediation, Waltham: Elsevier.

[2] Allan, I.J., Vrana, B., Greenwood, R., Mills, G.A., Roig, B. and Gonzalez, C. (2006), "A 'toolbox' for biological and chemical monitoring requirements for the European Union's Water Framework Directive", Talanta, Vol. 69, pp. 302-22.

[3] Amjad, U., (2004). Mobile Computing and Wireless Communications. NGE Solutions.

[4] Ayala, K. J., (2004). Microprocessor and Microcontroller. The 8051 microcontroller. 3rd ed. Cengage learning.

[5] Dworak, T., Gonzalez, C., Laaser, C. and Interwies, E. (2005), "The need for new monitoring tools to implement the WFD", Environmental Science and Policy, Vol. 8, pp. 301-6.

[6] Hejlsberg, A., Wiltamuth,S., Golde,P.,(2006). The C# programming language.2nd edition. Adobe Press.

[7] Papadimitriou, G. I., Pomportsis, A. S., Nicopolitidis, P., Obaidat, M.S.,(2002). Wireless Networks. New York: Wiley.

[8] Rabbany, A.E., (2006). Introduction to GPS: The Global Positioning System. 2nd edition, London: Artech House Publishers.

[9] Tolstrup, M., (2011). Indoor Radio Planning: a practical guide for GSM, DCS, UMTS and HSPA. 2nd edition. West Sussex: John Wiley & sons Ltd.

[10] Yang, X., Ong, K.G., Dreschel, W.R., Zeng, K., Mungle, C.S. and Grimes, C.A. (2002), "Design of a wireless sensor network for long-term, in-situ monitoring of an aqueous environment", Sensors, Vol. 2, pp. 455-72.