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Intelligent Mobile Monitoring and Control Network of Oil Pipeline Based on Internet of Things

Zhen-Dong Yang[1], Chao-Gang Xiang[2*], Tao Wang[1]
Hai-Yang Fang[1], Qiang Liu, and Fu-Xing Zong[1]

[1]Army Logistics University
University Town, Shapinba District, Chongqing, P.C 401311 - China
625771873@qq.com;wsxcg123@126.com;wangtao426@sina.com;15178709072@qq.com

[2]CCDC Drilling and Production Engineering Technology Research Institute
Guanghan City, Sichuan, P.C 618300 - China
*Corresponding author:wsxcg123@126.com

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Abstract. *Patrol on oil pipelines is the key point to ensuring normal guarantee of oil. The current manpower patrol, fixed video surveillance and patrol robot have high disposition and maintenance cost, and its hard to apply and promote these methods in a large scale. With the wide popularization and more functions of Smartphone, it has the capacity of perception, communication and disposition. Enlightened by crowd sensing, mobile phone++ is proposed in this article, which is an intelligent and mobile monitoring network system of oil pipelines based on Internet of Things. This system uses the existing sensor and processor of the Smartphone to the greatest extent to realize perception and disposition of information, and also applies the deployed mobile communication network to transmit sensing information, so as to realize mobile monitoring network system in a large scale at an extremely low cost. In this way, it solves the problem of high cost of large-scale monitoring and security and protection in the existing oil pipelines.*
Keywords: Smartphone, oil pipeline, monitoring and control network, crowd sensing

1. **Introduction.** Oil is the blood of modern wars, and as the important entity of oil guarantee, oil pipelines has undoubtedly significant position in both wars and logistical support. Typically, the oil pipelines will be laid in a long distance, and will go through poor environment and complicated social situations. However, oil pipeline may contain aging phenomenon in normal oil transportation, so as to cause leakage, and bad factors including man-made sabotage should also be prevented. Hence, regular patrol on oil pipelines at fixed points is necessary. Due to long distance of pipeline and complicated environment, many armed forces are generally needed, which both will take much time and many forces. The deployment of monitoring and control network (such as camera monitoring and control network) in a large scale has a high cost and poor flexibility. Although there exist some mobile patrol equipment in the market now, such as unmanned patrol robot and unmanned aerial photo equipment, the prices are generally high, generally about tens of thousands Yuan. The large-scale arrangement of these equipment costs a lot, and thus its hard to promote and apply that in a large scale. On the other hand, in unmanned aerial photography, the problem of low-air control is also involved, and patrol cannot be randomly carried out. Therefore, constructing a low-cost and large-scale oil pipeline monitoring and control network system is quite important.

With the development of Smartphone technology, the existing Smartphone is equipped with many existing sensors with powerful functions, such as GPS, camera, microphone, gyroscope and acceleration sensor, and the computing and processing capacity are constantly enhanced[1−2]. In the meantime, the communication network technique rapidly develops, including 3G, 4G and 5G, and the communication capability of mobile data network has also continuously improved. Enlightened by the thought of crowd sensing, the sensing, transmitting and processing capacity of the existing mobile phones have been utilized to the greatest extent in this article, and mobile phone++ is proposed herein, which is an intelligent and mobile monitoring network system of oil pipelines based on Internet of Things[3−12]. +1 refers to mobile phone mobile car. By using computing and processing capacity of mobile phone, the mobile phone is taken as the controller to control the intelligent movement of the mobile car, so as to realize intelligent mobile monitoring by combining with the sensor of mobile phone. +2 refers to mobile phone mobile communication network. This system uses the existing smart phone to realize a low-cost and large-scale intelligent and mobile monitoring network system without any additional deployment and other sensing communication device. And in this way, the problem of high cost of large-scale monitoring and control security and protection system in oil pipeline is successfully solved.

2. Intelligent Mobile Monitoring and Control Network System Based on Internet of Things.

2.1. System Structure. Enlightened by the new technology of Internet of Thins crowd sensing, the widely applied smart phone at present is utilized to the greatest extent to propose mobile phone++, which is an intelligent and mobile monitoring network system of oil pipelines based on Internet of Things. And then based on the networking of several mobile monitoring cars, the mobile control, video transmission and real-time positioning of all mobile monitored cars in the monitor area are realized in the mobile control center(such as computer, tablet PC and mobile phone). The system structure is as indicated in Figure 1.

It can be seen from Figure 1 that the mobile monitoring network system includes sensing layer, transmission layer and control layer. The sensing layer mainly consists of the mobile car and Smartphone, to carry out sensing monitoring by using the sensor on the phone, and with the combination with the mobile phone, it conduct intelligent mobile control on the car, so as to realize large-scale intelligent mobile monitoring. The transmission layer is the bridge between sensing layer and control layer, which mainly covers various mobile communication networks, such as cellular network, Wi-Fi network, etc. It will transmit the sensing data on each Smartphone at sensing layer to the control center in real time. Meanwhile, it will send the commands from the control center to each Smartphone at sensing layer in time. The control layer is the command control center and sensing data processing center of the whole network system and the main task of it is to process the sensing data of all mobile terminals, and control all mobile terminals.

(1)Sensing layer. The Smartphone is equipped with several sensors itself. On the one hand, the sensing devices on the phone such as camera and microphone are used to monitor the surroundings in real time, including video, photo, sound, and so forth. On the other hand, sensors such as GPS, acceleration sensor and gyroscope of the Smartphone are used to position the mobile car in real time, and the processing capacity of Smartphone is adopted to carry out intelligent control on the mobile car, to guarantee the mobile can will move in the right direction. Hence, at sensing layer, the intelligent mobile monitoring

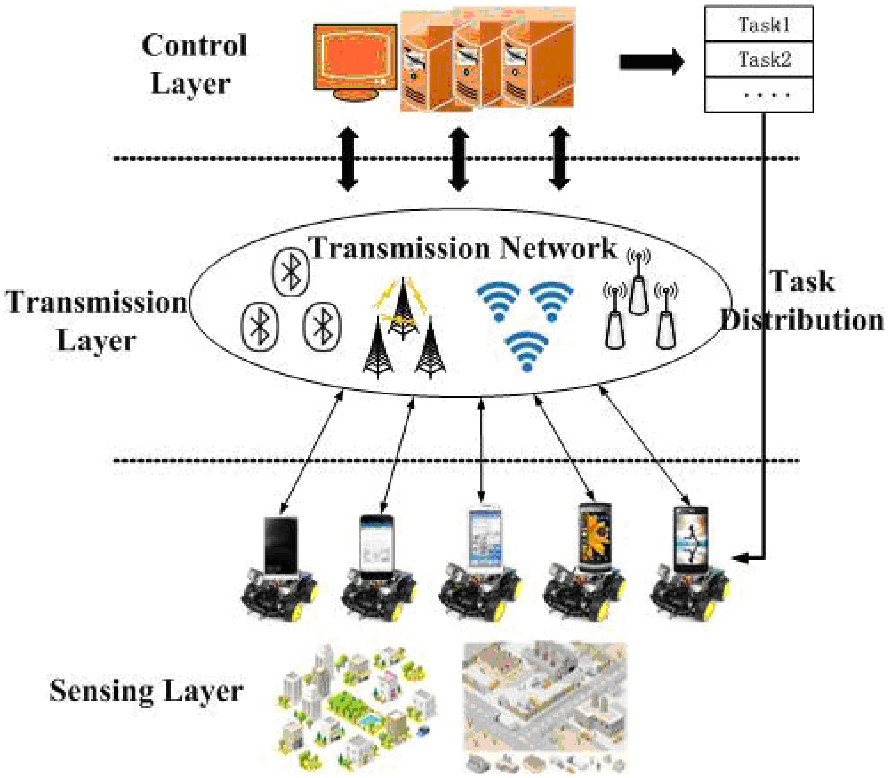

FIGURE 1. Structure of intelligent mobile monitoring and control network system

is realized through the monitoring sensing of Smartphone and its mobile control on the mobile car.

(2)Transmission layer. The operation of the whole monitoring and control network requires data transmission, so the main function of transmission layer is connection management, to divide and regroup data from the sensing layer and control layer, and also have capacity of error control, flow control and error correction. In this work, Bluetooth communication is adopted between the mobile car and vehicle-mounted mobile phone, and cellular communications or Wi-Fi communication is used between the vehicle-mounted mobile phone and control center [13–14].

(3)Control layer. The control layer mainly contains two functions. The first one is collection and processing of sensing data. In detail, the sensing and monitoring data of each Smartphone will be sent to the control center through the mobile communication network. The control center will collect and process all the sensing data, for example the real-time display of surveillance video and early warning of dangerous situation. The second is drafting and distribution of sensing tasks. Specifically, the control center will make sensing tasks and distribute to each mobile Smartphone based on the monitoring and sensing demand of the whole area and the situation of each mobile car(such as the current position, dump energy, sensing precision, etc.), mainly including the moving path of mobile car, time of monitoring, type of sensing data, and so on. So, the capacity of distribution of sensing tasks and processing of sensing data of the control layer are based on the vast establishment of mobile monitoring network system of the mobile Smartphone, so as to realize the real-time monitoring on the whole large-scale area.

2.2. **System implementation.** As indicated in Figure 2, the intelligent mobile monitoring network system mainly contains three modules, i.e., control center, vehicle-mounted Smartphone and mobile car. The mobile monitoring network system can realize functions including move control, receiving surveillance video, acquisition of real-time position and move in navigation route through the three modules.

(1)Move control. The module of vehicle-mounted Smartphone will obtain connection signal of message routing through the receiving and dispatching module and monitoring module, then the control center will send the connection signal through receiving and dispatching module, and the receiving and dispatching module of the vehicle-mounted Smartphone will constantly monitor the connection signal from the Smartphone at control center, and after it finds the connection signal, it will immediately notice the central control unit of the vehicle-mounted smartphone to connect the signal. Upon successful connection, the input module of control center will distribute data of movement path of each mobile car. After each vehicle-mounted smartphone receives the respective lath data through the vehicle-mounted Smartphone, the module of information analysis will analyze the data the receiving and dispatching module receives. Then, the analyzed data will be processed into movement command by the central control unit of the Smartphone, and send to the mobile car through Bluetooth module; the Bluetooth serial port of mobile car will send the movement command to single chip, and will convert the movement command into circuit signal and transmit that to the driver module of the drive motor to make the mobile car move.

(2)Receiving surveillance video. As mentioned above, after the module of vehicle-mounted Smartphone connects with the control center, the main control unit of control center will control the video remote processing module, to wait for the connection with video processing module of the vehicle-mounted Smartphone. Through video input module of vehicle-mounted Smartphone, it will initiate video capture signal, and send it to the central control unit of Smartphone. Then, the central control unit of Smartphone will start video processing module, and compress the video through the video processing module. The central control unit of Smartphone will send the signal data of the compressed video to the central control unit of the Smartphone at the control center through instant messaging platform. Then the central control unit of the Smartphone at control center will start video processing module to receive video data. Then the master control module will analyze the compressed video data, and the analyzed data will be displayed on the display by main control unit of the control center.

(3)Acquisition of real-time position. The process of acquisition of real-time position is similar with that of video signal. GPS remote read module will wait for connection with the GPS position acquisition module of the vehicle-mounted Smartphone. Then the signal of GPS position acquisition is obtained through location input module and monitoring module of the vehicle-mounted Smartphone, and the signal is sent to the central control terminal of the phone, and the central control unit will initiate GPS position acquisition module to acquire and collect GPS position. The generated location data will be transmitted to the receiving and dispatching module of the control center through the receiving and dispatching module of the central control unit of vehicle-mounted Smartphone. GPS remote read module will analyze the position data, and display the analyzed data on the display.

(4)Move in navigation route. After acquiring locating information, input the destination in the input submodule of the control center module, and then the main control unit will send the destination information command to the central control unit of the vehicle-mounted Smartphone through receiving and dispatching module. After the central control unit receives the command, GPS position acquisition module will locate the destination and provide corresponding planned path. After that, the central control unit will send the information of planned routine to the main control unit on the control center module. After the main control unit receives data, it will analyze data through analysis module. And finally the mobile control function will be initiated to realize the movement of car in the navigation route.

If several mobile cars accept control and dispatch of the control center in the same time, the information processing between each mobile car and the control center is just as mentioned above. The control center will adopt parallel information processing to carry out information interaction with several mobile cars, and in this way, it can simultaneously receive information from several cars and distribute corresponding tasks, so as to realize the purpose of networking.

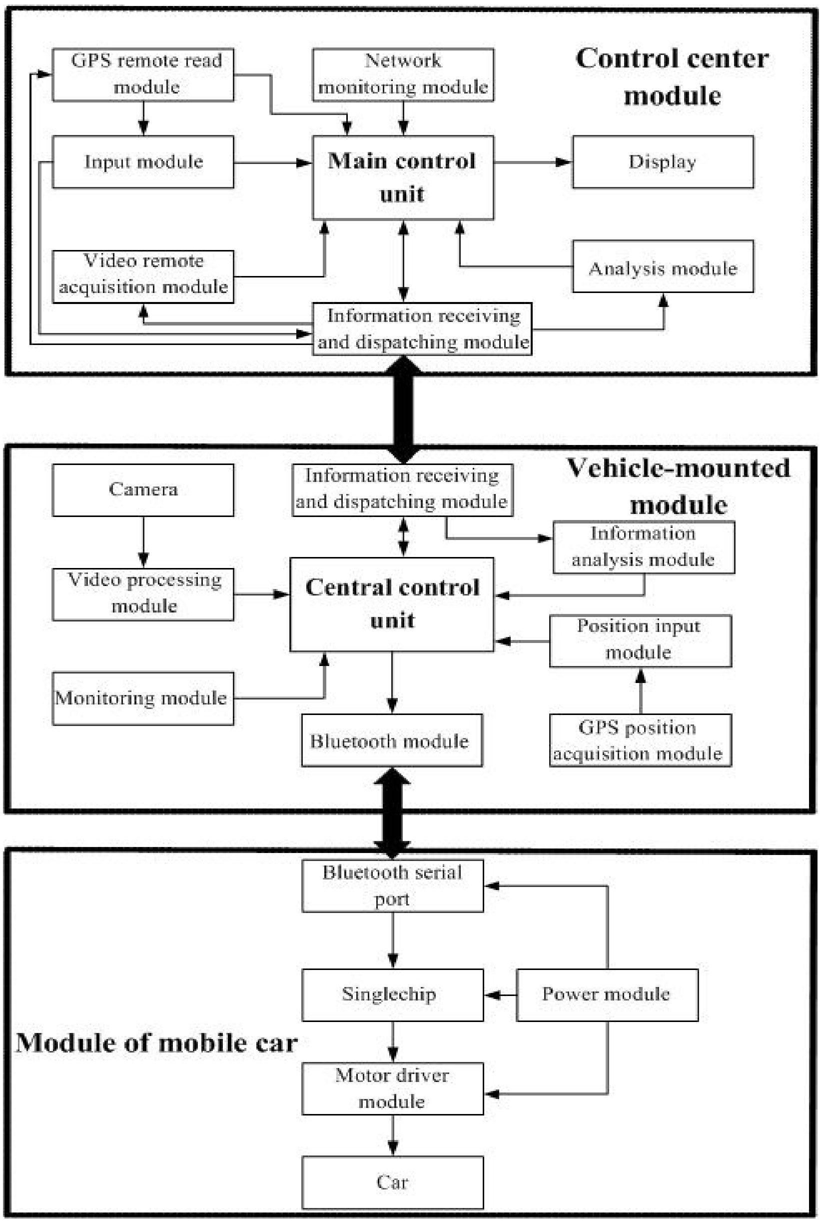

FIGURE 2. Schematic diagram of system implementation

3. **Experimental Results and Analysis.** The accessories of mobile vehicles are shown in Fig.3, including the wheels, the battery, the control component of mobility, and the communication component of Bluetooth. We compose these accessories into a car as shown in Fig.4 and Fig.5.

Figure 3. The accessories for the mobile vehicles of the system

Figure 4. Welding for composing the mobile vehicles

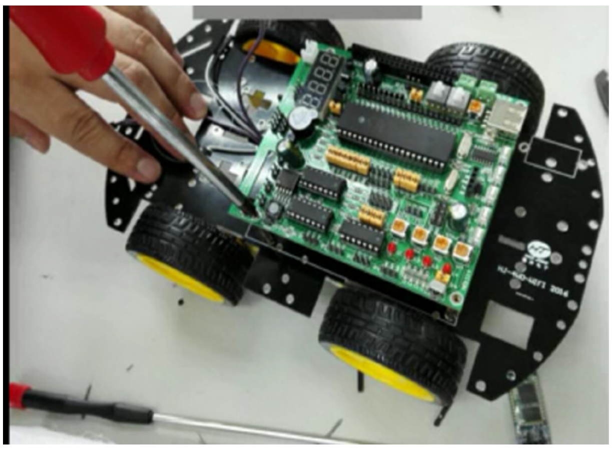

Figure 5. Composing the mobile vehicle

Moreover, we develop the mobile phone APPs based on Android platform, using JAVA language. We use the tools of Android studio, and combine the SDK of Agroa cloud vedio[15], the SDk of Github cloud communication[16] as well as the SDK of AMAP[17]. The interface of this system is illustrated in Fig. 6, Fig.7 and Fig.8. In addition, the basic working process of this system is as following. First, smartphone sends the control command to the mobile vehicle by the Bluetooth. After that, the mobile vehicle receives the control command, and use its equipped 51 single-chip micro-computer to control the mobility of this vehicle. Further more, the smartphone in the vehicle sends the localization information to the server and receives the control command information from server by the Github cloud communication platform. The smartphone in the vehicle sends the online videos based on the Agroa cloud vedio platform. We make the real experiments to use our proposed system for mobile monitoring in our university, as shown in Fig.9 and Fig.10. The practical experiments show that our system can successfully achieve the mobile controlling and monitoring of the oil pipelines.

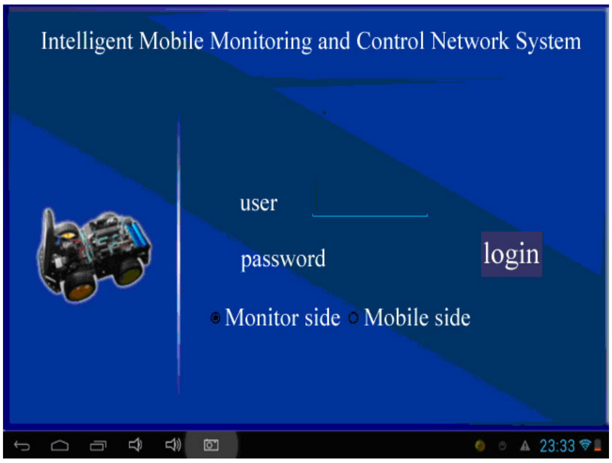

Figure 6. Login interface of mobile phone++

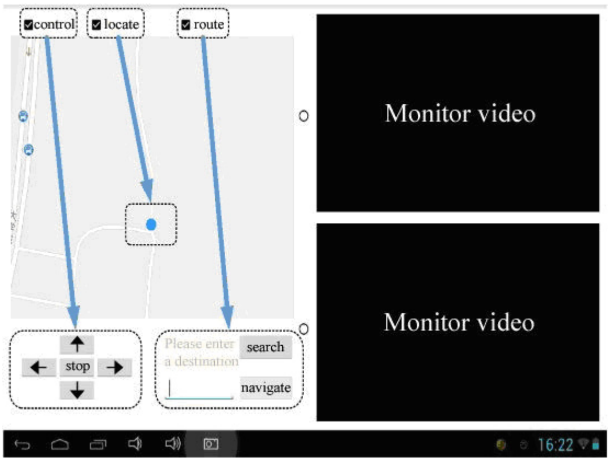

Figure 7. Main interface of mobile phone++

Also, we make the experiments to compare our method with the baseline method without the calibration based on IMU Smartphone sensors, in terms of different rotating angels of the mobile vehicles. We vary the rotating angels from 30 degrees to 270 degrees, and run the experiments for 20 times at the same settings. As shown in Fig.11, compared with the baseline method, our method can improve the rotating accuracy significantly, since we use the IMU sensors of smartphone (i.e. gyroscope) to assist the rotating amendment of vehicle. The maximum increase of rotating accuracy is up to 13.2 degrees, and the

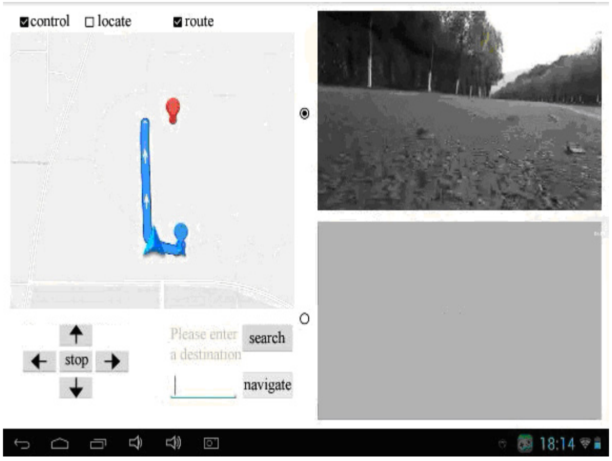

Figure 8. Monitoring interface of mobile phone++ based on navigation route

minimum improvement is 5.6 degrees. On average, the rotating accuracy of our method can increase by 8.6 degrees.

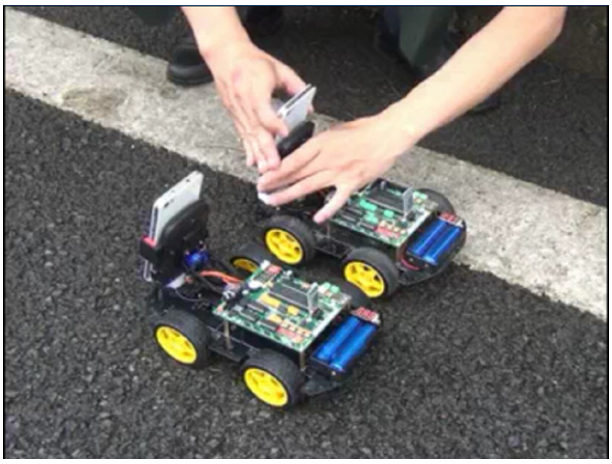

Figure 9. The initialization of the real experiments for the proposed system

Figure 10. The picture for the practical running of the system

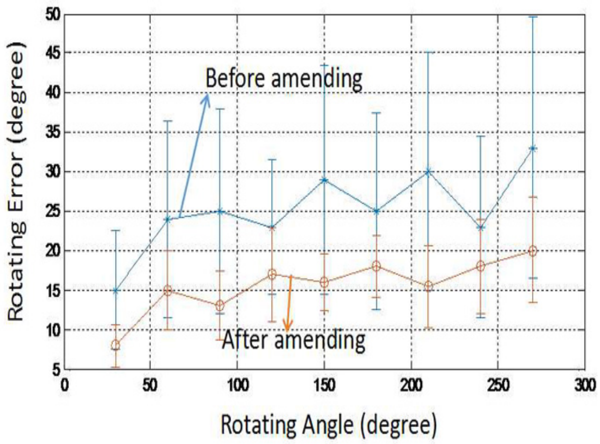

FIGURE 11. The comparison of rotating error

4. **Conclusions and Expectations.** With the arrival of Internet of Things, the conception of smart city and smart home has become more and more popular. Based on crowd sensing, mobile phone++ system is proposed in this thesis, which takes advantage of the capacity of sensing, communication and processing of the Smartphone to the greatest extent[18], and gives play to the large-scale popularization of Smartphone as its advantage, so as to realize large-scale security and protection monitoring in oil pipelines at the extremely low cost[19].

In this article, only the prototype system of mobile monitoring network system in oil pipeline is proposed and realized. In the following research, cooperation can be carried out with factories to design small mobile cars applicable for pipeline patrol. Then, with the combination of our Smartphone, monitoring and patrol on large-scale area of oil pipelines can be realized.

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