Automatic System for Roadway Safety – ASRS 01

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Abstract: - One of the objectives of the European Union (EU) as well as of other state authorities is to create safe roads for vehicles all over the EU space. Considering the rapid development of road traffic and, regrettably, an increase in the number of accidents, the system presented in this paper has the role of informing road traffic participants about infrastructure and environmental conditions. Hardware support, software support as well and further development of the ASRS 01 system is presented.

Keywords: - Automatic system, microcontroller, roadway, safety, sensors, wireless communication.

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1 Introduction

The condition of the weather and the roadway has always been of great importance in terms of road traffic safety. A large number of road accidents were due to bad weather or road conditions, but most accidents could have been avoided if the road users had been warned in time of the situation they were in and if they had adapted to the conditions on the road that were waiting for them. The main weather conditions that have caused a large number of road accidents over the years are fog and hail. The main problem is not the fog or the fog, but the failure to inform motor vehicle drivers and the failure to adapt to the situation in question, because if drivers were informed of the dangers on their route, accidents could be avoided. The autonomous system for informing road traffic participants is designed in such a way that as many road traffic participants as possible can be informed in real time about traffic conditions, to streamline and increase its safety. This paper presents the software support of the autonomous system for informing road traffic participants, the development environment, and the programming language in which it is made, everything is completed with a prototype of this system. This paper presents the ease and simplicity of implementing this system on a large scale because it has a low-cost price and increases road traffic safety by a large percentage because road traffic participants have time to adapt to the appropriate infrastructure and environmental conditions of the situation in question. Compared to all the systems that appeared on the market up to the given moment, the present work differs from them in that the system is autonomous and automatic. The system is autonomous because the entire system is powered by batteries and automatically, because all operations and decisions are made by a microcontroller, thus eliminating the human operator.

For example, radio stations Highway Advisory Radio Stations (HAR) of the United States Department of Transportation inform participants of the automotive traffic about the weather and traffic jam conditions. These are usually located near highways and densely populated locations, such as big cities and tourist locations. These systems are licensed by the Federal Communications Commission (FCC) in the United States of America to deliver a maximum of 2nV/m over 1.5 km. (0.93 miles) using up to 10 W to reach the limits when using vertical antennas (most commonly used). Evacuation systems in critical cases, such as those near chemical or nuclear plants, are allowed to use higher power in case of emergency. These systems, in special situations such as extreme emergencies of people evacuation can reach 100 W [1-4].

This concept is not limited to the United States, passenger information stations broadcast in Canada, France on certain highways also in Australia, Japan, in Italy where we meet Iso Radio, a radio station produced by RAI on the frequency 103.3 MHz frequency modulation (FM) [5-7].

Another example of such a system is Traffic Radio, a digital radio station from England. This radio station broadcasts traffic information for England's main roads and highways, run by the Global Traffic Network for the Highways Agency. Traffic Radio can be heard on digital radio stations (Digital Audio Broadcasting - DAB), 1386AM, but also on the

Internet. It is available 24 hours a day, every day of the year and the information is updated every 10 minutes during peak hours. It has to offer news about regional traffic, reports on specific areas, and national-level news [8, 9]. The information comes from the National Traffic Control Centre, which has 1,000 CCTV cameras and 3,750 sensors, and the seven regional command dispatches of the Highways Agency. Traffic Radio is not intended to compete with local UK radio stations, most of which also broadcast traffic information. This service runs 24/7, so drivers can immediately listen to the latest traffic information. All these systems presented above have the disadvantage that they need personnel to retrieve the information and pass it on [10, 11].

Another technology used in this area is the Traffic Message Channel (TMC). The technology transmits traffic and road information to traffic participants. For traditional FM radio stations, digital encoding is usually done through the FM-RDS system. Radio Data System (RDS) is a communications protocol that standardizes various types of transmission information, including date and time, station identification, and announcements. Radio Broadcast Data System (RBDS) is the American version of RDS. Originally a project of the European Broadcasting Union (EBU), the standard has become an International Electro-Technical Commission (IEC) standard. Both standards transmit data at 1187.5 bits per second on a 57 kHz subcarrier, so there are exactly 48 subcarrier periods per data bit period. The RBDS/RDS subcarrier is set to the third harmonic of the 19 kHz FM tone to minimize interference and intermodulation between the data signal, the FM tone, and the 38 kHz DSB-SC differential signal. TMC can also be transmitted via satellite radio or digital radio stations [12, 13]. It contains a list of 2048 phrases representing events that can be decoded by the TMC receiver in the language spoken by the user. Some expressions describe isolated situations, such as accidents, while others describe serious incidents that result in traffic jams. In Europe, location is integrated into maps provided by navigation systems from companies such as NAVTEQ and Tele Atlas. In some countries, such as the United States or Canada, private commercial companies own location tables and use TMC services for profit. Using the display module, different warning messages related to detected weather phenomena can be displayed. Data is transmitted to the control center via a GPRS modem. For example, the radar video recording module (SIV-R), equipped with an industrial computer, records the speed information of the radar and the image of the camera; when the speed information indicates that the set limit has been exceeded, the image captured by the camera is associated with the speed value, date and time, and location. The information is saved together. Information is stored on solid-state drive (SSD) storage media, ensuring storage of at least 1,000 images. The computer's connection to the Internet allows the photos to be automatically transferred to a central server for storage and processing of the information that the operator can access for viewing and use. The video recording module with flow monitoring SIV-AT is equipped with an industrial computer to collect weight information from the road traffic monitors and images from the camera; when the weight information indicates that it has exceeded the set limit, the image captured by the camera is saved together with the weight value, date and time, and location information. Store information in SSD storage media, ensuring at least 1,000 images are stored. The HSDPA USB stick connects your computer to the Internet, automatically transferring images to a central server for storage and processing of the information.

The remainder of the paper is organized as follows. A hardware description of the ASRS 01 system is given in Section II. The software support is described in Section III, while Section IV concludes the present work and gives a few directions for future research on the discussed topics.

2 Hardware Support of the ASRS-01

The block diagram of the ASRS-01 is displayed in Fig. 1.

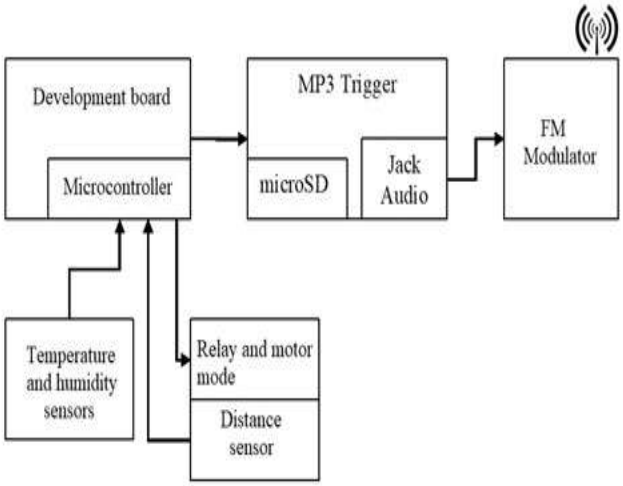


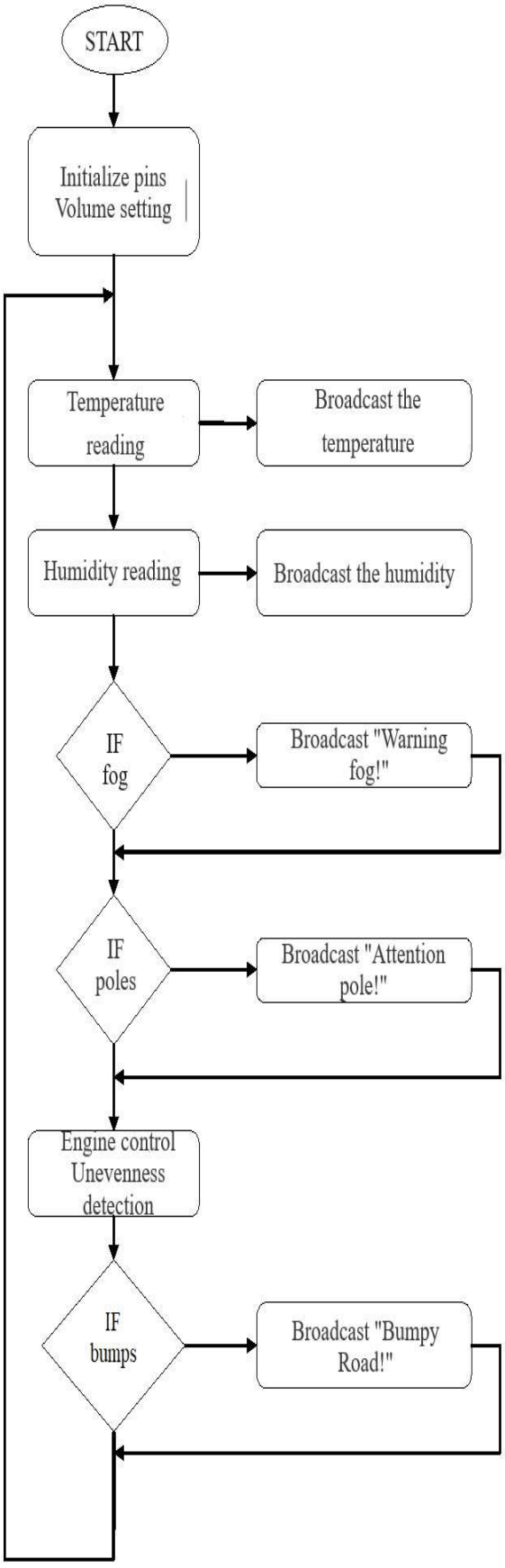
Fig. 1. The block diagram of the ASRS-01.

The components of this system are a development board with a microcontroller Arduino ATmega328; an MP3 Trigger with a micro SD flash memory on

which mp3 format files are stored and the Trigger plays them by outputting to the audio jack; FM Modulator transmits the signal received from the MP3 Trigger on FM radio waves; temperature and humidity sensor; relay and motor module; IR distance sensor. The system shown in Fig. 1 has the role of monitoring the state of the roadway and road conditions with the help of a microcontroller and a series of sensors. The information received by the sensors is processed by the microcontroller and transmitted further, in the form of recorded audio messages, by radio to the drivers of the vehicles that come within its range on a certain preset FM frequency. This system tries to improve traffic safety by warning the driver of the dangers and road conditions ahead so that he can change his driving style and adapt to the road conditions appropriate to the situation in question. The ASRS-01 system consists of a development board with a microcontroller that takes all the information from the environment with the help of three sensors (humidity, temperature, and distance). The Arduino Duemilanove has several facilities for communicating with a computer, another Arduino, or another microcontroller. The ATmega328 provides UART TTL (5V) serial communication, which is found on digital pins 0 (RX) and 1 (TX). An on-board FTDI FT232Rl centers USB serial communication and FTDI drivers (included with the Arduino software) and provides a virtual software COM port on the computer. The Arduino software includes a serial monitor that allows plain text data to be sent to and from the Arduino board. The RX and TX LEDs on the board will turn on and off repeatedly when data is being transmitted via the FTDI chip and the USB connection to the computer (but not for serial communication on pins 0 and 1).
A Software Serial library allows serial communication with all pins on the Duemilanove. The ATmega328 also supports I2C(TWI) and SPI communications. The Arduino software includes a Wire library to simplify the use of the I2C bus, and for SPI the SPI library is used [14 - 16]. With the help of the temperature and humidity sensors that are integrated into a physical capsule, the microcontroller will take the temperature and humidity from the surrounding environment, and with the help of some algorithms in the program, it will determine if the fog or fog conditions are met. The IR distance sensor is attached to the mobile part of the engine control assembly, also having the role of checking if there are pits or unevenness on the road surface. The engine control assembly includes two relays that control the direction of the engine and the IR distance sensor that has the role of determining the return and stop position of the engine. All this information from the sensors is processed by the microcontroller, which sends further to the MP3 Trigger a set of instructions to access the MP3 Trigger's micro SD flash memory where the warning and information messages recorded in mp3 audio format are found. Depending on the instructions from the microcontroller, the MP3 Trigger can play the following warning and information messages:
- Display temperature from -20 to 50 degrees Celsius with an accuracy of 1 degree Celsius. Example: "Temperature: 23 degrees Celsius";
- Display humidity from 0 to 100% with an accuracy of 5%. Example: "Humidity: 45 percent";
- Fog warning. When the conditions of fog, a relatively low temperature, and high humidity in the air are met, the MP3 Trigger will play the message: "Warning fog!";
- Pole warning. When there is relatively high humidity in the air and the temperature is below the freezing point of water, the MP3 Trigger will emit the message: "Attention pole!";
- Unevenness warning. After the IR distance sensor scans the road surface, if it finds a bump or a pothole it will issue the following warning: "Caution bumpy road!".
Furthermore, the MP3 Trigger emits an audio signal that reaches the FM modulator, the latter having the role of transmitting the messages on a pre-set FM frequency.

3 Software Support of the ASRS-01

Arduino uses the Processing development environment based on the C/C++ programming language. As a hardware project, Arduino uses the Wiring language and development environment. The Arduino development environment makes some minor transformations to ensure the correctness of the code in C or C++. The program files file is then loaded onto the board: and transmitted via USB or over the serial connection via the boot loader that is already on the chip or with external programming hardware.
For example, the Sharp distance sensor is a component that can be used with Arduino to measure the distance to various surrounding objects. The SHARP GP2D120XJ00F proximity sensor is only effective between 3 and 40 cm. In this case, the sensor is attached to a mechanism that moves with the help of a motor and is used to detect unevenness and control the direction of rotation of the motor.
We exemplify the broadcast program in the memory of the ASRS-01 system as follows:




```
int bump=0;
 digitalWrite(relay1, HIGH); //power relay 1
 digitalWrite(relay2, LOW);
 Serial.print("right direction\n");
 delay(200);
 do{
  delay(50);
  float volts = analogRead(IRpin); //read potential-distance
  Serial.println(volts);
  if(volts>400){ //potential at which the motor turns
   goto stop1;
   }
  volts = analogRead(IRpin);
  if(volts>200 && volts<350){
   bump++; //increment bump
   goto bump1;
   }
 }while(analogRead(IRpin)<400);
 bump1:
 delay(50);
 stop1:
 float volts = analogRead(IRpin);
 if(volts<400){
  Serial.println(volts);
  goto bump1;
  }
 digitalWrite(relay1, LOW); //change motor direction
 digitalWrite(relay2, HIGH); //power relay 2
 Serial.print("left sense\n");
 delay(200);
 do{
  delay(50);
  float volts = analogRead(IRpin);
  Serial.println(volts);
  if(volts>400){
   goto stop2;
   }
  if(volts>200 && volts<300){
   bump++; //increment bump
   goto bump2;
   }
 }while(analogRead(IRpin)<400);
 bump2:
 delay(50);
 volts = analogRead(IRpin);
 if(volts<400){
  Serial.println(volts);
  goto bump2;
  }
 stop2:
 digitalWrite(relay1, HIGH); // sequence used for countering
 digitalWrite(relay2, LOW); // inertia
 delay(20);
 digitalWrite(relay1, LOW); // stopping the engine
 Serial.print("Stop\n");
 if(bump!=0){
```

Fig. 2. Generalized activity diagram.

Setting the MP3 Trigger volume is done as follows:
Serial.write('v'); // set volume command
Serial.write(20); // volume value. 0 (zero) maximum volume to 64 minimum volumes
The mp3 files on the microSD memory card must be named in the format TRACKxxx.mp3, where xxx = 001 to 255 (e.g. TRACK001.mp3, TRACK010.mp3, etc.). Other file name formats will not work. Although "only" 255 files are possible, their size is not limited [17]. An example of a program that plays 10 seconds of all tracks on an mp3 is as follows:

```
void setup() {
  Serial.begin(38400);  //initialize serial communication at 38400 bps
  Serial.write('v'); // set volume command
  Serial.write(20);  // volume value. 0 (zero) maximum volume to 64 minimum volume
}
void loop() {
  piece = piece + 1;
  if (piece > 255) piece = 0;
    Serial.write('t'); // command play track
    Serial. write(track); // the value of the track to be played (between 0 and 255)
  delay(10000); //waits 10 seconds then moves to the next track
}.
```

4 Conclusion

In this paper, an autonomous system for informing road traffic participants is presented. On a large scale, the role of this system is to automate the way of informing road traffic participants, thus increasing safety and smoothing of traffic. Because this system is autonomous and automatic, it can work around the clock, day and night, unlike the previous systems in which qualified staff is needed to operate the system. The appearance of the "human factor" decreases the stability of the system because of fatigue, stress, and even routine errors that lead to the wrong information about motor vehicle drivers. The simplicity and low-cost price of this system make it easy to implement at the national level, or even internationally, if the messages sent are in an international language.
As can be seen from the hardware description, this system is autonomous because it can be powered by batteries, so it can be placed anywhere, without the need for power cables, and because all devices are of low power, the batteries can last a long time before they are recharged, compared to the other systems where a radio broadcasting station is needed which has a relatively high consumption. Also, the system is automatic, with all operations and decisions being made by the microcontroller, while the others require experienced personnel to operate and maintain the system.
Another important feature is the system's versatility, as it can be easily implemented in railway or even naval traffic. Due to the low price of all devices, this system can be implemented on a large scale, thus covering a larger information surface and safer and more fluid car traffic.
A main characteristic of this system is its autonomy, being powered by batteries that must be recharged at certain periods. In the future, batteries could be replaced or recharged by green energy sources such as photovoltaic and wind energy. Thus, warning messages related to fog, poles, and the condition of the road are issued, but as a future development, ASRS 01 system will deliver more information about the ambient environment and the safety of the road by modeling it with Deep Learning algorithms with the help of several sensors such as vehicle wheel adhesion sensors, road roughness sensors, control system to avoid aquaplaning of the vehicle, dynamical tire pressure control system correlated with the condition of the road.

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The authors have no conflicts of interest to declare that are relevant to the content of this article.