Design and Development of Low Cost Navigation and Security System for Indian Fishermen

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Abstract

The fishing industry plays a major role in the development of Indian economy. The recent attacks on fishermen taking place in Indo-Srilanka and Indo-Pakistan maritime boundaries have been major concerns. These attacks are primarily caused by the lack of navigation and security features during the voyage. Hence the current situation demands the implementation of precise facilities for reducing man and material loss.

The design and implementation of a Low cost Navigation and Security System for Indian fishermen on Arduino Nano platform are described. The system developed solves the above mentioned issues by continuously tracking the location of fishing vessel and providing minimal security features. The system ensures that navigation is in safe zone within the nation's maritime boundary and also prevents crossover. This is acheived using GPS receiver which directly links to GPS satellites for current location of the vessel. The required data fields such as the latitude and longitude data along with the time stamps are extracted from the GPS samples and used for determining the exact location of the vessel. The Proposed method aids in the detection of corner cases when the vessel is nearing or about to crossover for the maritime boundary, which cannot be marked physically. The method is useful for triggering conditions such as enabling or disabling the fuel injection system, the warning beeps and display notifications to the fishermen. Manual override facility for restarting the engine in case of crossover for limited duration is provided. The security features such as authentication for the genuine operator to get access to the engine panel, the support for distress message and the storage of the exact time stamps and GPS locations after encryption in case of initiation of transmitting distress message is provided as a blackbox feature. A password based mechanism allows a maximum of three attempts to unlock access to the control panel. The GSM modem allows for transmission of distress message to the registered base station/coast guard. The encrypted GPS samples and the time stamps are stored in the on-chip EEPROM memory for future reference.

Key Words: Beverage Vending Machine System, ARM, LPC2148, LCDs, ATM

1. INTRODUCTION

The practice of apprehending Indian fishermen, along with their boats, has been followed by Sri-Lankan Navy and Maritime Security Agency (MSA) of Pakistan. The Indian Coast Guard or the Indian navy does the same to Pakistani and Sri Lankan fishermen, due to which poor fishermen on all sides have suffered [1].

1.1 Maritime Problem: India-Sri-Lanka

The Tamil Nadu factor in Indo-Sri Lankan relations that had been quiet for long has come to the surface in the form of the fishermen issue. Frequent incidents of fishermen from Tamil Nadu getting shot in the Sri Lankan's maritime boundary have enraged all citizens of the state. From Tamil Nadu about 18,000 boats of different kinds carry out fishing along the India-Sri Lanka maritime border. Ever since violence broke out in Sri Lanka two decades ago, fishing activity has not been peaceful. Tamil Nadu fishermen are arrested, or shot, by the Sri Lankan Navy. From the fishermen's point of view, straying takes place inadvertently, due to sheer ignorance about maritime boundaries. At times, the drift is because of engine failure or strong currents [2]. At the same time however, quite a few Indian fishermen engage in free floating to exploit marine resources in Sri Lankan waters, knowing very well the risks involved in crossing the International Maritime Boundary Line (IMBL). Growing markets for marine resources has forced Tamil Nadu fishermen to take risks across the Indo-Sri-Lankan IMBL as shown in Fig. 1.

Fig. 1 Graphical Representation of India-Sri-Lanka Maritime Border [3]

1.2 Maritime Problem: India-Pakistan

The long-standing territorial disputes and military conflicts between India and Pakistan have led to vigilant and strict patrolling of territorial waters in the Arabian Sea and the coastline shared along the Indian state of Gujarat and the Pakistani province of Sindh by the Maritime Security Agency of Pakistan and the Indian Coast Guard. The absence of a physical boundary and lack of a proper demarcation leaves small fishing boats and trawlers susceptible to illegally crossing territorial waters. The problem is aggravated by the dispute over the Sir Creek in Kutch and the failure to officially determine the maritime boundary between the two nations. Most local fishermen possess no navigational tools and are unable to determine their location by longitudes or latitudes. Even the terrorists responsible for 2008 Mumbai attacks gained entry through sea route after hijacking a fishing boat as represented in Figure 2 [4]. Indian authorities estimate and admitted about the fishing boats be strayed [5]. During periods of improvement in bilateral relations, the governments of both the nations have taken steps to release imprisoned fishermen as a confidence-building measure and a gesture of peace and goodwill. In 2006, Pakistan released more than 400 Indian fishermen (including 30 children) and India reciprocated by releasing 130 Pakistani fishermen, but claimed that as many as 350 fishermen were still languishing in Pakistani jails.

Fig. 2 Sea Route Taken by the Terrorist for Mumbai Attack [3]

2. REQUIREMENT ANALYSIS WITH FUNCTIONAL DIAGRAM

The functional block diagram for the proposed system with adequate peripheral interfaces is shown in Fig. 3. The input is fed to the system from the GPS. The system is primarily driven by the current GPS locations of the fishing vessel. The data from GPS receiver is received in standard NMEA (National Marine Electronics Association) format in the form of packet digital data. An input keypad module is used to facilitate the entering of password for user authentication of operator. The output peripherals consist of a display unit to show various message notifications to the operator in runtime conditions. The EEPROM memory is used to support the storage of GPS data along with time stamps in case of distress signalling emulating black box support. The actuators for fuel injection cut-off function during boundary crossover conditions and a buzzer for generating warning beeps to aid fishermen, while nearing international maritime boundary, are also provided. The GSM modem is also interfaced for supporting the delivery of distress message to base station or coast guard. The processing logic for the system is split up across two computing platforms of similar specifications. The reasons for using two platforms include the lack of adequate amount of GPIO pins for interfacing certain peripherals and the need for multiple UART protocol compatible transmitter and receiver pins.

3. DESIGN AND DEVELOPMENT

Fig. 4 shows the proposed flowchart processing logic on platform board-1 for the given system.

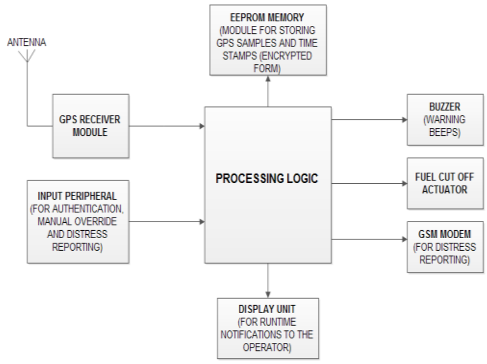


Fig. 3 Functional Block Diagram for the Proposed System

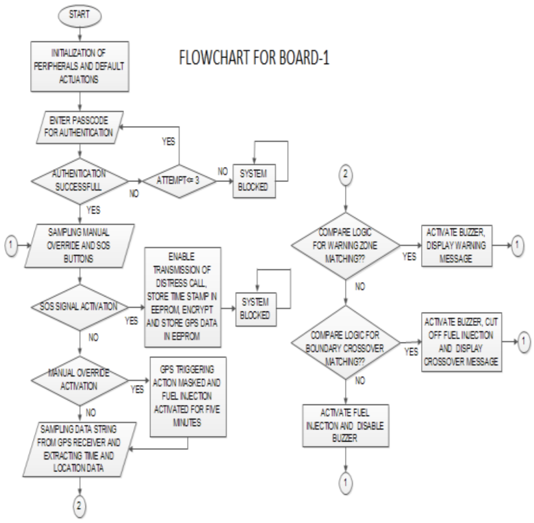


Fig. 4 Flowchart for Processing Logic Platform Board-1

Board-1 will be interfaced to the keypad module, GPS receiver module and the actuators for triggering actions of fuel injection cut-off in case of boundary crossover. The logic on platform board-1 interacts with logic on platform board-2 signalling exact indicators for the message strings to be displayed under various scenarios. It requests a signal for enabling transmission of distress message in case of 'SOS' button initiation, since platform board-2 will be interfaced to the LCD and the GSM modem (AT & T).

The data flow for logic on board-1 is given below:

Step 1: The output ports for LCD display indicators, distress message indicator, fuel injection status and warning beep are initialized and the reference GPS boundary locations and password are set. The password functionality is initiated. User or operator authentication procedure is initiated.

Step 2: During the authentication operation, a maximum of three attempts to enter the password are allowed. The system shall be blocked on exceeding the three attempts. Upon successful authentication, control is switched to the servicekey function.

Step 3: In servicekey function input from the custom keypad is sampled, if input is 'E', then SOS functionality is performed by enabling request signal for distress message transmission to platform board-2. Then the time stamp from GPS samples is stored on-chip EEPROM memory ranging from 20th location to 23rd locations (i.e. 'hh-mm' format).

Step 4: The GPS locations are encrypted by passing the coordinate values to the cipher algorithm ('encrypt' function). The individual numbers are separated and checked by the cipher algorithm. In every case, the character to replace each number is read from a global character array (named as 'Elements') using the number itself as the index pointer. The encrypted character for each number is stored in another global character array (i.e. named 'Results').

Step 5: The encrypted GPS locations are read from the global character array (named 'Results') and then stored in EEPROM memory ranging from 24th location to 27th location, while also updating SOS notification through LCD display indicators.

Step 6: If the input sampled is 'F', then the manual override functionality is enabled and the fuel injection is enabled and the buzzer is disabled for the next five minutes irrespective of the previous triggering conditions while updating the LCD display indicators. Upon completion of five minutes, the control flow is transferred to the GPS sample function. If both SOS and manual override conditions are not detected, the control flow is directly switched to the GPS sample function.

Step 7: In the GPS sample function, the availability of GPS data is checked by reading the status of a serial buffer. Once data is available, the samples are captured in a character array. The sampled data in the string buffer is scanned for finding '$GPRMC' (Recommended Minimum Specific GPS/Transmit Data) string. Upon successful match, the data from various positions in GPRMC packet is retrieved and bifurcated with the help of index to the locations of particular data. The time stamp is extracted as hours and minutes while the GPS locations are extracted in terms of latitude and longitude degree. Latitude and longitude minutes are also extracted, with position reference from NMEA format

Step 8: Rest of the data from other fields of GPRMC string are ignored. The selected data retrieved which is in character form is typecast and converted to integer format through some small computational operations, with a view of comparing them against the pre-specified reference GPS boundary locations.

Step 9: The control flow is then passed to the GPS compare function where the condition check for the appropriate latitude and longitude degrees are done by comparing sampled GPS values and pre-specified reference boundary locations. Upon a failed condition, the fuel injection is cut-off, buzzer is enabled and notification of cut-off is updated on LCD display indicators. Upon pass condition, the condition check for warning zone for enabling the buzzer is carried out, in case the vessel is nearing maritime boundary (i.e. 2 nautical miles maritime boundary). Upon pass condition the buzzer is enabled and warning messages are updated on LCD via display indicators.

Step 10: In case the warning zone condition fails, the condition check for boundary crossover is carried out, if the vessel approaches maritime boundary (i.e. 1 nautical mile before maritime boundary). Upon pass condition, the fuel injection is cut off and the buzzer is enabled simultaneously updating the crossover notification through LCD display indicators. Upon failed condition, the fuel injection is enabled and the buzzer disabled indicating that the vessel is in safe zone. The control flow returns to Step 3 and the process iterates infinitely.

The platform board-2 is interfaced with the LCD and GSM modem. The algorithm running on board-2 is developed to sample indicators for particular message strings on LCD under various scenarios (i.e. Authentication messages, Warning beep messages, SOS status messages, Manual Override messages and Fuel cut off messages). The algorithm also monitor sample requests for enabling transmission of distress message to base station by sharing the registration number of vessel as shown in Fig. 5. The data flow is depicted by the algorithm given below:

Step 1: Initialising the input pins for LCD display data indicators and for distress message request signal.

Step 2: Initialising the LCD, defining its display format and setting the cursor.

Step 3: GSM is initialised, setting its workable baud rate. Then conditional logic is checked for GSM initialisation status.

Step 4: The function lcd_decoder () is called, where the LCD display data indicators from board-1 are sampled and based on the data received, the appropriate value is passed to lcd_disp() function.

Step 5: Based on the value received from lcd_decoder() function, the lcd_disp() function executes the particular case. The function also displays the message string within the case on LCD.

Step 6: Now in function lcddisp(), a switch-case condition is evaluated and depending on the outcome, an appropriate messages will be displayed by LCD (i.e. Enter Passcode, Authentication Successful, Wrong Passcode Please reattempt, Maximum attempts reached system is blocked, Warning zone reached, Crossed Boundary fuel is cut off, Manual Override activated and SOS detected distress call made).

Step 7: The gsm_send() function reads the status of request for transmission of distress message (i.e. gsm_en signal) which is an active low signal.

Step 8: If gsm_en signal is enabled, system send the distress message with stored registration number of the vessel to the pre-specified base station number. An acknowledgement for the sent message is followed and returns to Step 4 and iterates infinitely. If gsm_en signal is disabled, the flow directly returns to Step 4 and iterates infinitely.

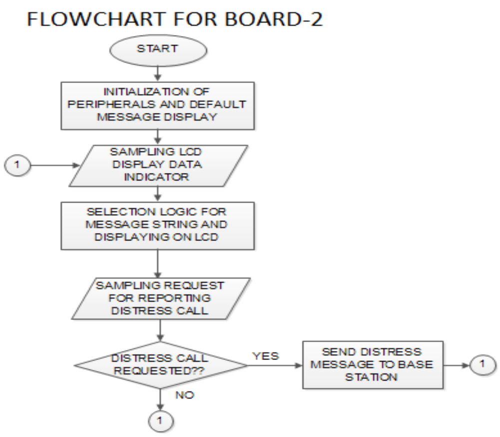


Fig. 5 Flowchart for Processing Logic Platform Board-2

3.1 Implementation

The algorithm implementation was carried out in Arduino 1.0.3 IDE using C language and some Arduino specific constructs for deployment on Arduino Nano platform. Arduino Nano is a very small and portable board, built around ATmega328, which is an 8-bit RISC architecture based microcontroller. The LCD is used in only write transactions via 4-bit interface from the microcontroller board; hence the LSB data pins (D0, D1, D2 and D3) are grounded. The entire system development using Arduino is shown in Fig. 6.

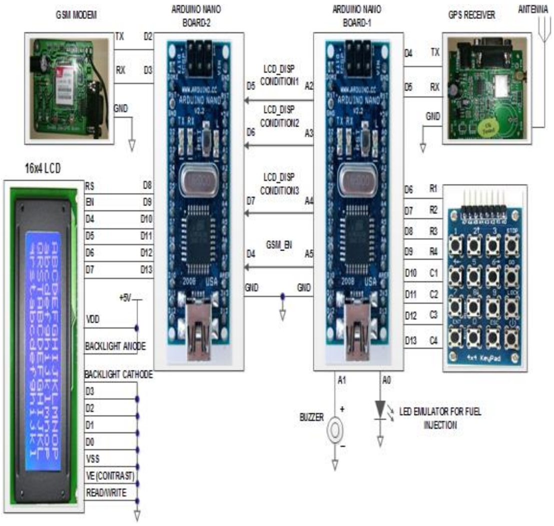


Fig. 6 Implementation of the System

4. RESULTS

Fig. 7 shows the experimental geo points used for testing the system. The locations around 'REF' tag point represents the safe zone, within which the vessel is allowed to navigate and fuel injection is enabled. The area around the inner sphere marked by N1, S1, E1 and W1 tag point represents the warning zone where the warning beep from buzzer is to be enabled. The area around outer sphere marked by N2, S2, E2 and W2 tag points represents the cut off zone where the fuel injection is to be disabled and the warning beep is to be enabled. Table 1 captures the condition for vessel in warning zone and the corresponding notifications on serial terminal and LCD.

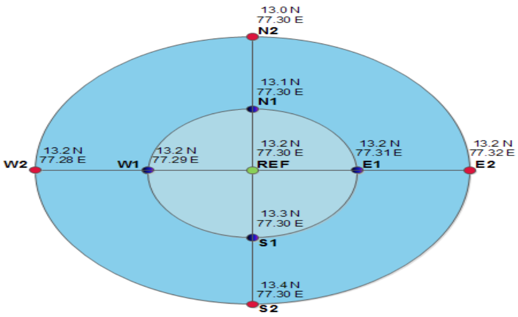
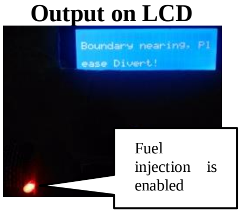
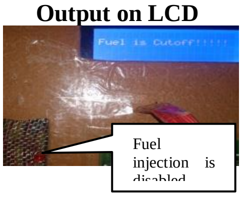
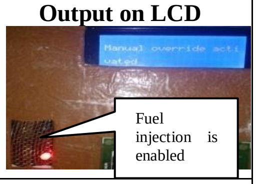


Fig.7 Geo-points used for System Testing

5. CONCLUSIONS

Based on the results of the various test cases, system functionalities were validated. The test results agree that this solution is capable of identifying maritime boundary between countries and provides navigation by enabling various triggering actions under varied conditions. The security features included in the system will have a big role in ensuring the safety of the fishermen.

Table 1. Test Cases and Results

Test Case 1	**Vessel location in warning zone**
Output on Serial Terminal GPRMC recd Time= 173915 Date= 051213 Latitude Deg= 13 Latitude Min= 2 Longitude Deg= 77 Longitude Min= 30 Warning zone reached	**Output on LCD** 
Test Case 2	Vessel location in cut off zone
Output on Serial Terminal GPRMC recd Time= 180927 Date= 051213 Latitude Deg= 24 Latitude Min= 0 Longitude Deg= 121 Longitude Min= 0 Degree Crossed Boundary Crossed, Fuel is Cutoff	**Output on LCD** 
Test Case 3	Manual Override initiation
Output on Serial Terminal GPRMC recd Time= 173743 Date= 051213 Latitude Deg= 13 Latitude Min= 2 Longitude Deg= 77 Longitude Min= 30 Warning zone reached Manual Override initiated	**Output on LCD** 
Test Case 4	Initiating of distress message
Output on Serial Terminal COM21 Board1 messages Longitude Min= 31 Minute Crossed Boundary Crossed, Fuel is Cutoff SOS signalling detected, Sending distress call COM32 Board2 messages status=GSM MODEM IS READY Sms request received SMS sent OK	**Output on LCD** 

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