Project documentation

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Safety device for small vessels

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Project Objective

The project aims to assist small boats and ships with a low cost device in order to warn the vessel about ships in vicinity to avoid collision, notify the vessel when it is roaming out of territorial waters of the country, and send SOS messages to coast guard during state of emergency.

Design

The device primarily works by receiving AIS signals emitted by ships in its vicinity. AIS data contains NMEA sentences which can be parsed to obtain various parameters like MMSI, latitude, longitude and other details of nearby ships. The distance between our vessel and nearby ships is calculated by applying haversine formula on the coordinates obtained from GPS (installed on our device) and coordinates of ship from NMEA data. If the distance comes out to be less than a specified limit, say 1 km (configurable), an audible warning is given, which can also be silenced for a specific time period via press of a button. The device also incorporates a system to detect if the vessel is out of territorial waters and provides an audible warning when a file specifying the coordinates of territorial water is provided. The device implements another novel feature to broadcast SOS messages during state of emergency when a manual input is given.

Components

• DVB-T Dongle (For receiving AIS signals)	2500/-
• 12V Bike Battery (Rechargeable)	1000/-
• 3 x LM2596 Voltage Step Down Module	150/-
• Raspberry Pi 3	2300/-
• GPS Shield	1500/-
• Relay Module	70/-
• Bike Horn	150/-
• Solar Panel (24V)	3500/-
• VeroBoard	50/-
• LED and Jumper Wires	50/-
• Arduino	450/-
• RF transceiver	150/-

Assembly

The Block diagram for the assembly is given below.

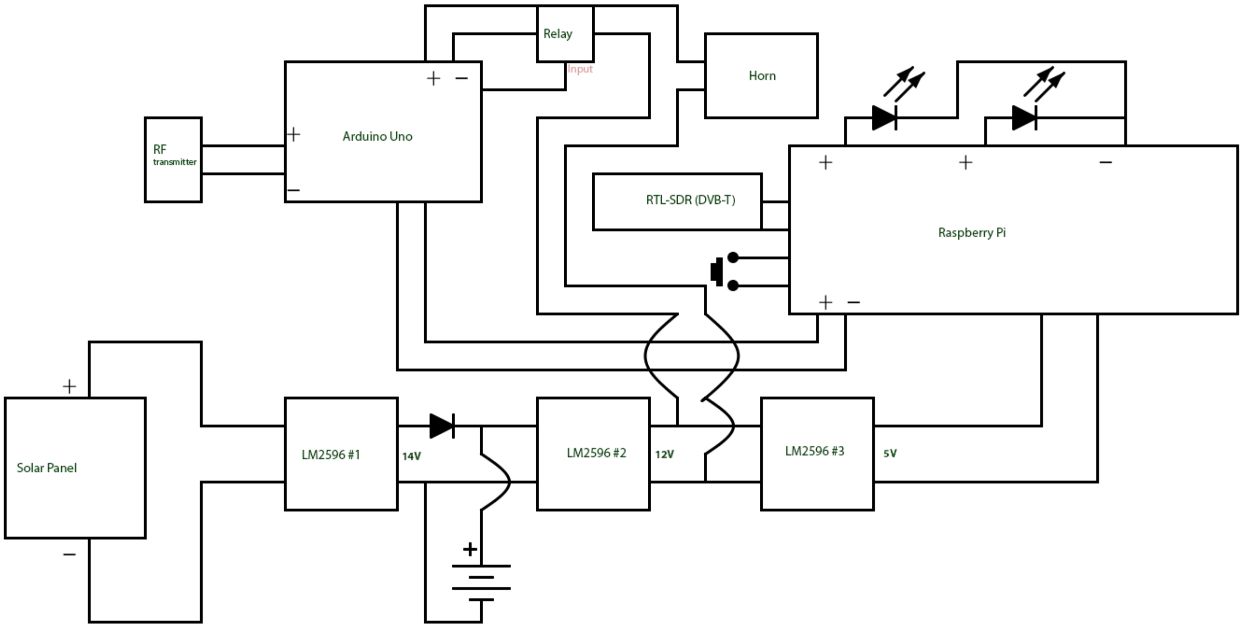

Figure 1: Block diagram of circuit used

Electronics

The Solar panel, in general, provides a potential difference of 18-22V across its terminals. The voltage is stepped down to ~14V via a single LM2596 module. The terminals of the module are connected to bike battery along with a diode in between to prevent reverse flow of current. The first module is further connected to another similar module to output a voltage of ~12V to power the horn. This voltage is further stepped down to 5V to power Raspberry Pi, GPS Module, DVB-T Dongle (device to capture signals in range 25-1700 MHz), relay switch and Arduino Uno. GPS Module, DVB-T Dongle and Arduino is connected to various pins and ports of Raspberry Pi. A relay switch and RF transmitter is further connected to Arduino. The bike horn is controlled by passing its circuit through the relay module which can be controlled through the Arduino by sending specific instructions as serial data from the Raspberry Pi, thus controlling the opening and closing of the horn circuit. A button is also provided so that the fisherman/sailor can silence the horn for a specified amount of time (configurable) after the warning has been dealt with. If the same silencing button is pressed three times rapidly SOS messages are broadcasted through RF Module which contains data like Boat ID and current coordinates of the boat.

Code

The code is written in Python 3 for Raspberry Pi. The code uses multiprocessing python modules in order to achieve various tasks like signal processing and GPS data acquisition asynchronously as waiting for one I/O and computation may result in loss of valuable AIS data and too little utilization of Pi's processing power. Also the blinking of LEDs require separate processes. The code uses many widely used standard libraries like NumPy and matplotlib (for computing the position of a point with respect to a polygon) as well as pyNMEA for parsing GPS NMEA strings, libAIS for parsing AIS NMEA strings, geoPy for haversine formula, RPi.GPIO for LED and horn control, Serial Library for serial communication with Arduino etc.

We have also extracted the coordinates of territorial waters of Indian Mainland, Andaman & Nicobar Islands and Lakshadweep Islands using QGIS and data from http://www.marineregions.org/downloads.php for use in boundary tracking feature in our device.

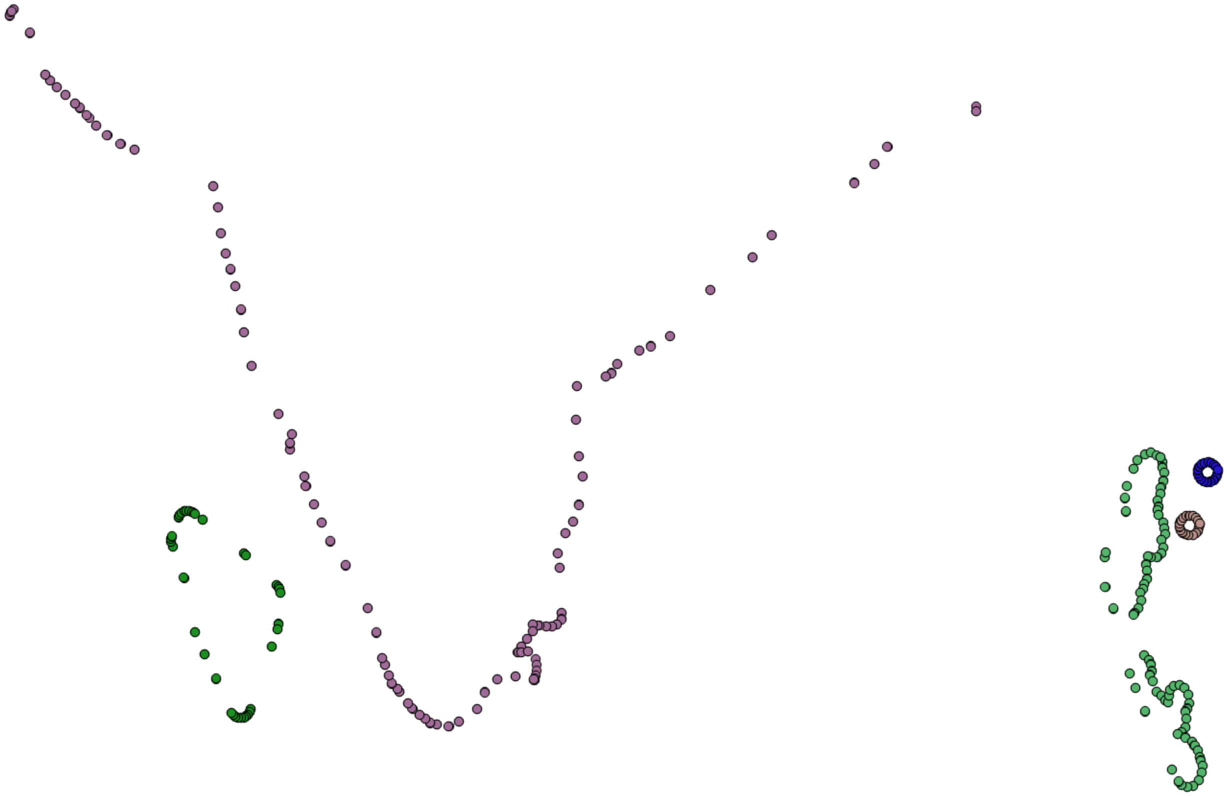

Figure 2: Territorial waters of India defined by latitude-longitude coordinates

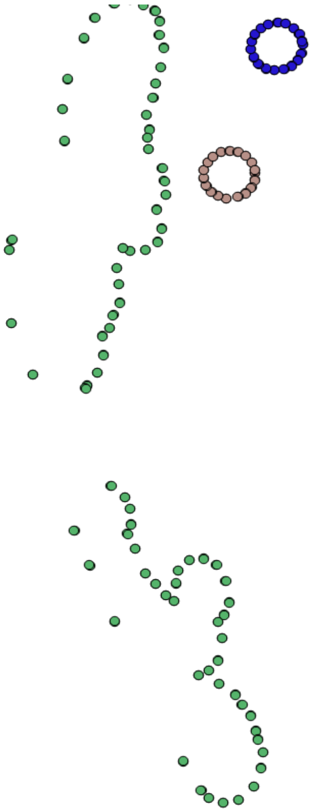

Figure 3: Territorial waters of Andaman-Nicobar defined by latitude-longitude coordinates

All softwares used in the code is open source and free to distribute in nature.

The flowchart of the code is given below for better visualization. The flowchart shows the main loop in program which continues to run until given some interrupt.

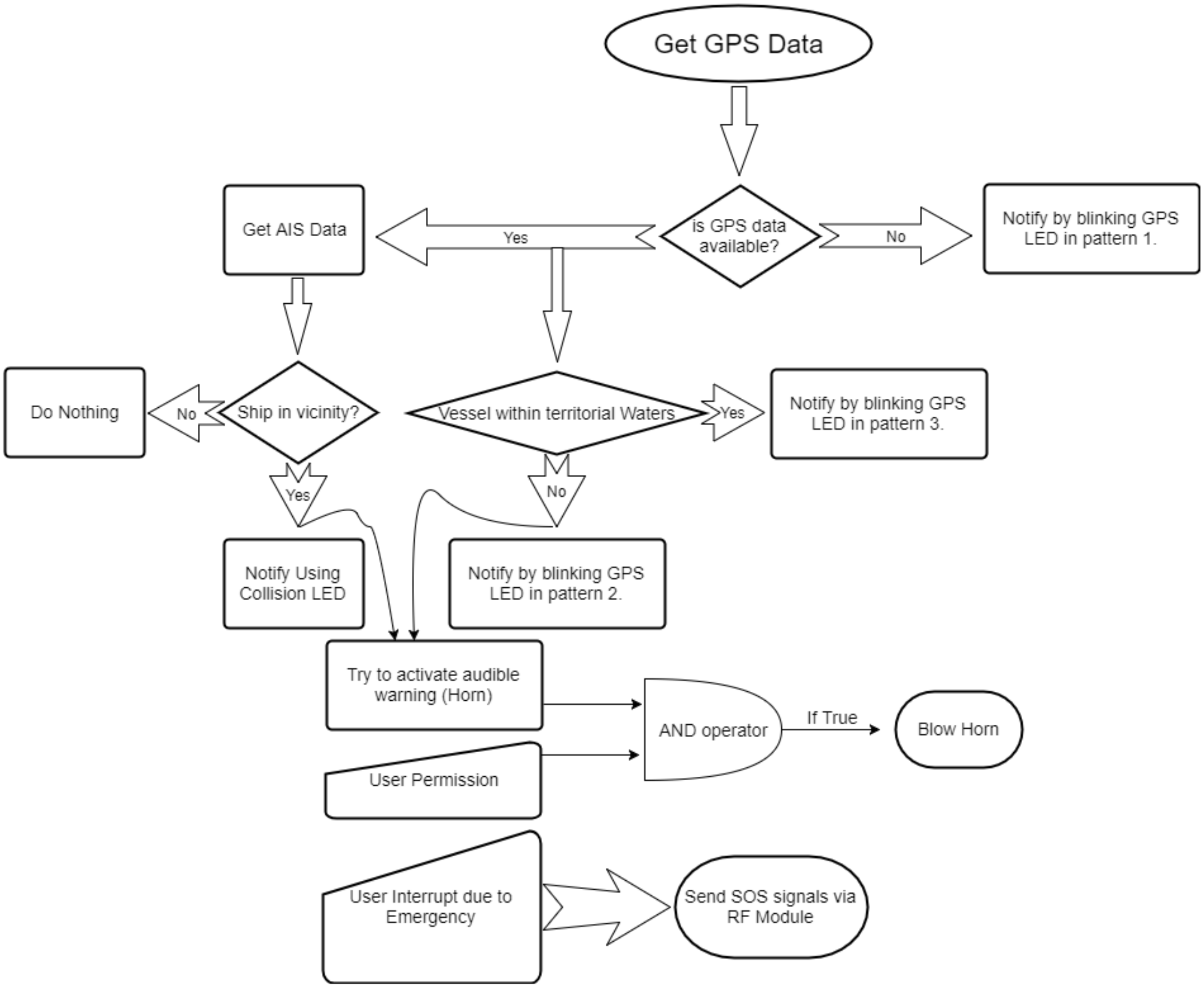
Get GPS Data
is GPS data available?
Yes
No
Notify by blinking GPS LED in pattern 1.
Get AIS Data
Do Nothing
No
Ship in vicinity?
Vessel within territorial Waters
Yes
Notify by blinking GPS LED in pattern 3.
Yes
No
Notify Using Collision LED
Notify by blinking GPS LED in pattern 2.
Try to activate audible warning (Horn)
AND operator
If True
Blow Horn
User Permission
User Interrupt due to Emergency
Send SOS signals via RF Module

Figure 4: Block diagram of logic used in each loop of code

Budget and resource consumption analysis

Budget

The total cost of components mentioned above sums up to be ₹11870 which below 12 thousand INR. Plus, the maintenance of the device is zero which results in zero hassles for the user of the device. Also the device suffers no downtime. In our case, the battery comes with an 18 months warranty. So, our device can be considered as an investment due to its merits and longevity until and unless the circuitry has been tampered with.

A very cheap receiver can also be provided to the coast guards for listening to incoming SOS messages. It can be integrated to their existing PCs further lowering the cost.

Power Consumption

The Bike Battery has a capacity of 9 AH. And the model proposed by us uses at max 2W of power. So under full load, a full charged battery would be able to sustain the device for 54 hours without charging.

Since we have equipped the device with solar panel, that has a power output of 50W at 24V and charges the battery at ~14V at around 40W, a completely dead battery can be charged to full in 3 hours of clear sunlight or 5-6 hours of dim sunlight.

CPU Resource Consumption

The device never uses above 30-35% of pi's processing power. A pi not under full stress the whole time can function properly for very long runs of time.

Market analysis

Our prototype costs below 12 thousand INR and we expect the cost to drop to 8-9 thousand INR if the prototype goes into mass production. The existing alternatives (AIS class-B module) costs north of 40 thousand INR. Furthermore, existing AIS modules are serving single purpose of dealing with AIS messages while our prototype is a multipurpose one. The cost of our product pits it at one fourth's price of currently available alternatives. Upon subsidization, mass adoption by small fishermen is possible.

Our product not only warns the fishermen of ships in vicinity but also prevents them from roaming out of territorial waters which is a huge problem in states like Gujarat and regions near Sri Lanka which are sharing borders with foreign countries and small vessels unknowingly cross the territorial waters and enter other country's territory. This, most of the time, results in dire consequences for the occupants of the vessel. Furthermore, it is an assurance of help in case of God forbid, any mishaps as RF module can send all necessary details for rescue.

The product is never a liability but a long term investment for small vessel owners and save them from facing many unforeseen circumstances and cut out a lot of hassle.

The final product could be further improved by minimizing the electronic circuit using various microcontrollers instead of pi, which would further aid in increasing the efficiency and decreasing the cost. It was not possible to implement microcontrollers due to lack of time, manpower and R&D facilities.

References

Materials Referred

- www.rtl-sdr.com
- https://nada-labs.net/2017/rf-to-bytes-rtl-sdr/
- www.rhydolabz.com/wiki/?p=420
- https://en.wikipedia.org/wiki/Automatic_identification_system
- https://witestlab.poly.edu/blog/capture-and-decode-fm-radio/
- http://whiteboard.ping.se/SDR/IQ
- http://www.marineregions.org/downloads.php

Softwares Used

- PyRTLSDR
  https://github.com/roger-/pyrtlsdr
- libAIS
  https://pypi.python.org/pypi/libais/0.7
- GeoPy
  https://pypi.python.org/pypi/geopy
- Python 3
  https://www.python.org/
- QGIS
  https://www.qgis.org/en/site/
- Universal Radio Hacker
  https://github.com/jopohl/urh
- GNU Radio
  https://www.gnuradio.org/
- RTL-AIS
  https://github.com/dgiardini/rtl-ais