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An Error Correcting System For Marine Boundary Identification

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***Abstract*— The navigation tools play a major role in finding the routes of the ships. The boundary detection technique does not allow the fishermen to cross their country border. When they reach the country limit an alarm will be raised and the message will be sent to the base station at the shore through the GSM module. The new system adapts the embedded architecture based on ARM and Linux real time operating system as the software. The ARM is used as the core processor because it has high definition, less power consumption. Positioning module may be affected by EMF and inorder to maintain the accuracy of the device extended kalman filter algorithm is implemented.**

***Keywords*— Extended Kalman Filter, ARM9, Linux.**

I. INTRODUCTION

In the development of embedded technology the device which is to be used in ship for boundary detection must be of less weight, less power consumption and should be flexible for real time environment. The proposed system adopts the embedded architecture based on ARM9 which has many features when compared to any other processor and Linux as the software platform which suits the real time processing.

[1] At present there are few existing system which are used in identifying the current position of the boat/ship using the GPS system and view them using an electronic map. When the vessel arrives or departs the accuracy of detecting by manual leads to error. [2] To know the distance between the destination point and the current location harvesine formula is used, which gives the distance between two points from their longitude and latitude. [3] Automatic identification system, digital selective calling and inmarsat-c are used for vessel identification and monitoring purposes. It uses ROSS DSC500 pro which provides the full range of very high frequency one way communication which sends the message to the base station on the shore through digital selective calling. The Ericsson module is used for sending the message. [4] For vessel monitoring system GPS/LORAN is used.

In this navigation is based on different time intervals between the received signals from the pair of radio transmitters. The fleet of vessel can be closely observed by comparing GPS tracking with the offshore sensor radar. This system was very much useful in olden days when the vessel used to carry hazardous oil/gas. The transport is very risk and often the vessel may be grounded due to heavy load and an alarm is generated when the vessel goes out of the path or when it is grounded. Vessel traffic service provides information such as the depth of the sea as well as some hazards to the base station. [5] In the inertial navigation system the embedded vehicle dynamic is used to find the position, velocity. The INS generates the noise and inorder to filter it the extended kalman filter is used to estimate and compensate the error. It uses the sensor such as magnetic compass, depth pressure sensor and inclinometer to find the position and velocity. [6] Inertial navigation system mostly uses suboptimal method and for optimal approach the combination of the kalman filtering along with particle filter is used. Kalman filter is used for solving the error estimation depends on the linear process. [7] Delay update filter is used for handling the mismatch of the tracking system. The navigation system to identify the target it uses the target tracker algorithm. The steady state filter gain of the DUF is used for constructing the constant gain filter. [8] The GPS is being used for accurate navigation. In underwater or other planet the GPS is unavailable and for providing the vision aided navigation a camera is equipped with a three view geometry. The navigation error and image noise inaccuracies can be filtered by using the unscented filter. The UKF filter is used because the accelerometer bias is estimated in a better way using UKF and it has no linearization. [9] The system has three modules such as Vessel tracking module, RADAR identification module and up gradation. If there is no response from the coastal guards the message will be sent to the higher authorities regarding the details of the vessel that crosses the boundary.

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II. EXTENDED KALMAN FILTER

In order to improve the system's capability, operation of multi sensor systems increased recent years. Some methods are required for the system to use the sensors effectively and to integrate the data which the sensors provide to system. In multi sensor systems, as the data coming from each sensor serve as a separate input to the system combination and integration of the data before using became the actively research area. Kalman filter is used for processing the data in the dynamic processes. It is characteristic recursive computation is particularly effective for multi sensor systems. Sensors in a multi sensor system are different hardware device which have their own data processing technique. If a standard central Kalman filter optimally processes all the measurement, outputting a result and covariance matrix, it may create a great calculation burden. Design is divided into one master filter and various local filters. At the first stage local filters process their data in order to make best local estimates. At the second stage master filters integrate local estimates and form the best global estimate.

The extended Kalman filter **(**EKF**)** is the nonlinear version of the Kalman filter which linearizes about an estimate of the current mean and covariance. The primary drawback of the Kalman Filter is that it is the optimal estimate for linear system models with additive independent white noise in both the transition and the measurement systems. Unfortunately in engineering most systems are nonlinear, so some attempt was immediately made to apply this filtering method to nonlinear systems. The EKF which adapted techniques, namely multivariate Taylor Series expansions, from calculus to linearize about a working point became the working solution. If the system model (as described below) is not well known or is inaccurate, then especially particle filters are employed for estimation. Monte Carlo techniques predate the existence of the EKF but are more computationally expensive for any moderately dimensioned state-space. In the extended Kalman filter, the state transition and observation models need not be linear functions of the state but may instead be differentiable functions.

$$X_k = f(X_{k-1}, uk_{-1}) + w_{k-1}$$

$$Z_k = h(X_k) + v_k$$

Where $\mathbf{w}_k$ and $\mathbf{v}_k$ are the process and observation noises which are both assumed to be zero mean multivariate Gaussian noises with covariance. The function *f* can be used to compute the predicted state from the previous estimate and similarly the function *h* can be used to compute the predicted measurement from the predicted state. However, *f* and *h* cannot be applied to the covariance directly. Instead a matrix of partial derivatives (the Jacobian) is computed. At each time step, the Jacobian is evaluated with current predicted states. These matrices can be used in the Kalman filter equations. This process essentially linearizes the non-linear function around the current estimate.

The GPS may fail due to some reasons such as ionospheric delay propagation, tropospheric delay propagation, ephemeris data error. Inorder to retrieve the current location even if the GPS fails the extended kalman filter is being used. Sensors connected to it retrieve the position. The EKF has two steps time update (prediction) and measurement update (correction). The filter can start with either step, but begin with the description of the correction step. The correction step makes correction to an estimate, based on new information obtained from the sensor. The state of the vector of variables that completed specifies enough of initial boundary positions. The solution for propagating that solution forward in time is called state prediction. The model for propagating the covariance matrix of estimation uncertainty is derived from the model used for propagating the state vector.

Prediction

Prediction state estimate

$$X_{K/K-1} = F_K X_{K-1/K-}1 + BKuk_{-1}$$

Predicted estimate covariance

$$P_{k/k-1} = F_k P_{k-1/k-1} F_k^T + Q_k$$

Update

Kalman gain $k_k = P_{k/k-1} H_k^T S_k^{-1}$

Updated state estimate $x_{k/k} = x_{k/k-1} + k_k y_k$

Updated estimate covariance

$$P_{k/k} = (I - K_k H_k) Pk_{/k-1}$$

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III. HARDWARE DESIGN

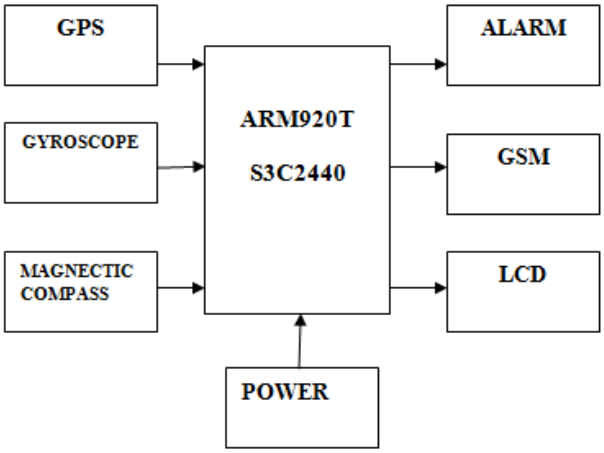

Figure 1

The hardware module of the device includes the processor core module, human- computer interface module and power supply module. The central processor core module is S3C2440 processor based on the ARM920T as the core. The ARM9 is the friendly man machine interface which has higher clock frequency. By increasing the clock frequency, instruction cycle and adding the memory management the performance of the ARM9 has been heightened when compared to 89C52 microcontroller.

The S3C2440 processor has the frequency running about 405 MHz and can reach a maximum of 530MHz. The entire embedded platform guarantees fast processing and quick speed response of system from the hardware. The system links with GPS receiver which supports the NMEA protocol. The NMEA combines electrical and data specification for communication between marine electronic such as gyrocompass, echo sounder, GPS receiver and much other type of instruments.

It uses the simple ASCII, serial communication protocol that defines how data are transmitted in sentence form and communication rate of which is 4800bps using the UART. The GSM module is used for sending the message to the controller room at the shore which includes the information of the ship, position including the latitude and longitude which is displayed through the LCD.

Gyroscope is used for measuring or maintaining the orientation based on the angular momentum principle. It is a spinning or disc which has the axle free to assume external torque. It consumes low power and has high stability over temperature. The magnetic compass is the navigation instrument that shows the direction that is stationary relative to the surface of the earth. It contains a magnet that interacts with the earth's magnetic field and aligns itself to the magnetic poles.

IV. SOFTWARE DESIGN

System software based on embedded Linux. The device has a control system of real time collection, whose requirement of the real time of the system is very high therefore we need to adapt the Linux operating system which is based on the high real-time as the software of the device.

Linux is a Unix like computer operating system assembled under the model of free and open source software development and distribution. Linux distribution is an operating system built on the top of Linux kernel and often around a package management system. Linux distribution usually includes a very large collection of free and open source software of all sorts.

The whole software is divided into several independent modules and every module performs its own separate function, the data sharing among the modules must be minimum. The priority of modules is given by time critical method, the higher real time module is given the higher priority inorder to meet the requirement of the system.

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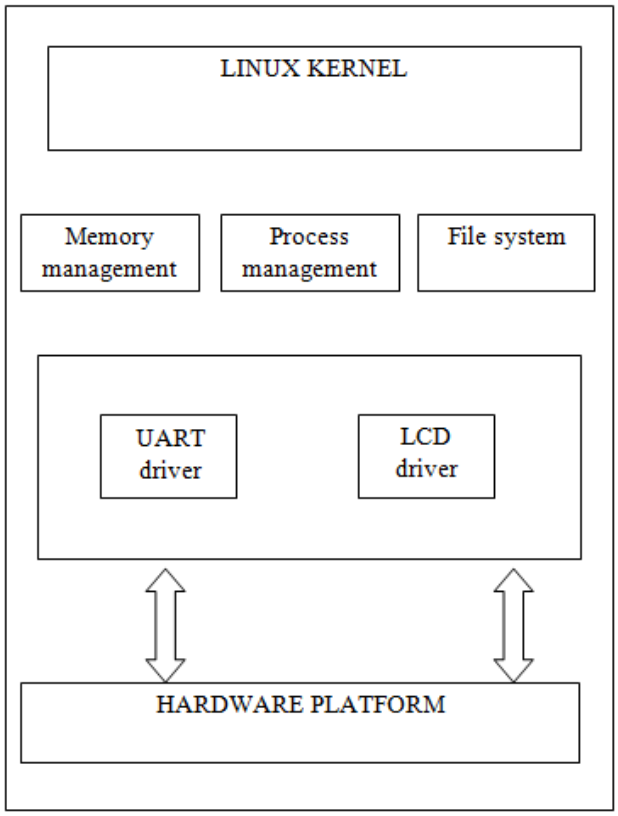

Figure 2

The first module is information input which accomplish function that exchange information with the outside world for the device. All the information will be in the form of command packet. The second module is command information processing which is core of the control software. It extracts the data from the command packet inputting from the port and take the data of the tracked object.

V. SIMULATION

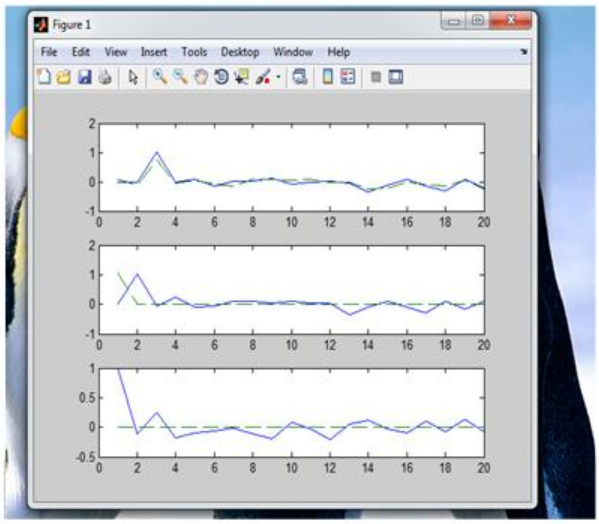

Figure 3

The process saves the actual state and the measured state then the extended kalman filtering is implemented to find the estimated state and the process is updated. The second plot represents the actual measured state and the third plot represents the estimated state.

VI. CONCLUSION

The error correction system for boundary detection using the extended kalman filter algorithm prevents the fisherman from crossing the boundary limit by giving an alarm signal. The ARM processor S3C2440 has guaranteed fast response speed, it is convenient man machine interaction with friendly operation. For the quick speed of data exchange the real time Linux operating system is used. The GPS must able to withstand the EMF, which is used to minimize the error. The existing system identifies and gives an alarm but GPS can be failed at times. By using the sensor and implementing the EKF the position can be retrieved which saves the life of the fishermen. The accuracy of the device is obtained and maintained using the extended kalman filtering algorithm.

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