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PLC Based Control and Monitoring in Ship

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Abstract: **The safety and security of ship is very important, especially in passenger and cargo ships. A large number of human lives have been claimed by many ship related accidents. Fire outbreaks onboard ships is one of such common accident. So safety is critically important in each and every compartment of the ship. Similarly, security is also a big concern, especially in ships with larger capacity. Providing security to every area of the ship is a difficult task. So as part of this project we focus only restricted area where authenticated people can access the control actions. This paper demonstrates, a control and monitoring system in ship based on Programmable Logic Controller (PLC) that ensures both safety and security. Fire detection for safety and iris recognition for security are the two parameters considered in this paper. Fire sensor, Smoke sensor, thermocouple are the sensors used in fire detection. Iris recognition is one of the biometric identification methods, that make use of the unique characteristics of the iris and has many advantages compared to other methods. For authentication, iris images of authorized people are stored in the system and is used for comparison for granting access.**

Keywords: **PLC, Fire sensor, Smoke sensor, Fire detection, Iris recognition.**

I. INTRODUCTION

Safety and Security of the passengers and the crew members, plays a vital role in a shipping organization. Shipping companies gives prime importance to all safety measures. A fire on a ship is one of the most dangerous incidents which can lead to the loss of human lives, cargos and other properties in the ship. If the fire is detected at the earliest, the crew can prevent larger damages by taking preventive measures. The number of ships damages due to fire and collision is increasing every year. Electrical short circuits, spontaneous combustion etc are the major causes of shipboard fire. Careless smoking also sometimes leads to countless fires that break out when no one expects. The engine room is at higher risk because of high temperature, oilfired boilers, overheated bearings ,leaky pipings carrying oil, and even the accumulation of other waste (tins of oil , dirty oil, oil rags, etc.). Hence fire safety is given atmost importance. Fire fighting at sea consists of three seperate stages: detection, alarms and control. This paper demonstrates detection of fire using programmable logic controller (PLC) [1]. Detectors are the devices that can sense fire,smoke or over heating. Mainly we use three types of detectors - fire sensor,smoke sensor and a thermocouple in this project. The detector input is then fed to the PLC and whenever fire or smoke is detected, an alarm is raised along with a message displayed in Human Machine Interface (HMI). At the same time a pump will be actuated to control the fire.

Security of the ship is also very important. The importance of maritime security has substantially increased with the increase in the number of outsider attacks like sea snatchers. Many such incidents are reported in the past. Authentication of every person in the ship is a difficult task. This project focus mainly the control room. Today's e-security are in critical need of finding secure, cost-effective and accurate alternatives to personal identification numbers (PIN) and passwords as computer-based fraud such as identity theft and computer hacking is very common. To achieve more reliable identification or verification we should use something that really characterizes the given person. Biometric solutions gives a solution to these fundamental problems, because an individual's biometric data cannot be transferred and is unique. There are lots of biometric techniques available nowadays. Here an IRIS Recognition method is used. An iris is the coloured ring of textured tissue that surrounds the pupil of the eye. Twins have different iris patterns, even left and right iris are different too. Research shows that the matching accuracy of iris identification is more than that of DNA testing. After authentication, system allows the person to access the control systems and restricted region of the ship.

There are many methods available for ensuring the safety and security of the ship. The paper titled 'Simulation of Intelligent Fire Detection and Alarm System for a Warship' [2] uses a microprocessor based fire detection system .Even though fire detection is accurate and fast, the system has got some disadvantages. High level language is used for the program development, hence more memory is required. It also does not have any control actions like actuating fire extinguisher. Another paper titled 'Multi-Sensor Fire Detection Algorithm for Ship Fire Alarm System using Neural Fuzzy Network' [3] explains a MSFDA based on fuzzy interference neural network. But the system needs a strong knowledge of fuzzy and neural network. A PIC1684A microcontroller is used for the fire protection in paper titled 'Design and Implementation of an Automatic Fire Extinguishing System Based on Fault Secure Multi-Detectors' [4]. But the installation cost of this system is too high. The proposed system detects the fire accurately and also provides some control actions to extinguish the fire. Since controlling is based on PLC the system is very reliable and flexible. The programming of PLC is also simple. Overall system gives a cost effective solution for the safety and security in ship.

II. PROPOSED METHODOLOGY

Block diagram and Working principle

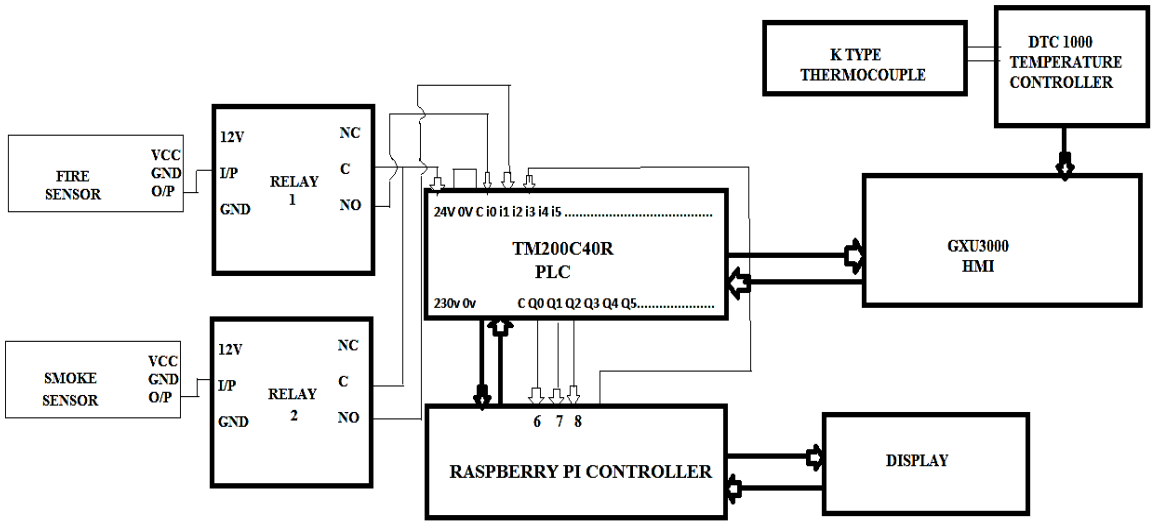

Fig. 1: Block Diagram

A. Fire Detection

Fire sensors and smoke detectors are installed in all sensitive locations like engine room, engine control room, cargo room passenger room etc. If fire is detected due to any reason in any of the rooms, fire sensor output raises to 5V actuating a Relay. Relay convert 5V output to 24V and fed to PLC. PLC then power on the motor and also raises an alarm. A warning message "FIRE DETCTED" is also displayed in the HMI at the same time. In the same way if smoke is detected, output of smoke sensor goes to the PLC through the relay, PLC enables the buzzer output and "SMOKE DETECTED" message is displayed in HMI. Since engine room is always at high temperature, we are using a J type thermocouple. Thermocouple detects the change in temperature and if the temperature in the engine room goes higher than that of the normal temperature, the thermocouple output goes high and message "ENGINE AT HIGH TEMPERATURE" is displayed in HMI along with alarms. This is how the proposed fire detection in this paper works.

B. Iris Recognition

Since PLC does not have a storage device to store the iris images, Raspberry Pi controller is used for matching and storing images. Anyone who wants the access, first needs to enter the password to launch iris detection application. If the password is correct, PLC tells the controller to launch a window wherein, iris image captured using iris scanner, is given to the controller, it matches the image with that of stored ones and grants access. Due the budget constraint, image capturing part using iris scanner is not part of this project. Instead we use already captured images for the demonstration. On successful matching, controller sends an indication to HMI via PLC and it displays message 'ACCESS GRANTED' allowing people to access and control the system like set engine threshold temperature, control the engine (start, stop, forward and reverse), light control etc. Conversely if there is a mismatch, HMI displays 'ACCESS DENIED'.

III. HARDWARE ELEMENTS

A. Fire Sensor

The Fire sensor, is a built-in module used for detecting the fire up to a range of 1 meter. The module consists of IR sensor, comparator, potentiometer and an on-board Light Emitting Diode (LED) for visual indication. The module is weighing about 5 grams and it can be easily mounted anywhere that needs protection against fire. The sensor module gives a high output when it is detecting the fire. The potentiometer is used for adjusting the sensitivity of the module.

Fig.2: Fire Sensor

Working

The fire sensor module has got 3 pins VCC, GND and output. The Working voltage of the sensor is 5V.The module consists of IR sensor, comparator and an indicating LED. When the IR receiver LED detects the fire, the output pin of the sensor goes high and indicating LED glows. The output pin can be connected to the input of the controller and the same can be used for any fire detection applications.

B. Smoke Sensor

Monitoring of produced gases is important in every scenario. Smoke or Gas sensor plays an important role in the detection of different type of gases from home appliances, vehicles and different type of industries. Smoke sensor is a built in module that can detect smoke of various concentration. Smoke sensor module mainly consists of MQ gas sensor, LM358N comparator, Resistors, Potentiometer, and Indicator Power LED

Fig. 3: Smoke Sensor

The important part of the smoke sensor module is MQ gas sensor. The gas sensor module includes a steel exoskeleton under which a sensing element is situated. The module also includes six connecting leads. Heating current is passing through this connecting leads to the sensing element .When the gases coming close to the sensing element, the gases are absorbed by the sensing element and get ionized. As a result the resistance of the sensing element varies which changes the amount of the current going out of it.

c. Thermocouple

Thermocouple, resistance temperature detector and thermistor are the sensors commonly used for temperature measurement. Thermocouple is a popular sensor used for a large temperature range .it has got wide acceptability because

of its simple construction and low cost. The working principle of thermocouple has been discovered by Thomas seebeck in1821.He discovered that when two wires that made up of dissimilar metals are connected at both ends, and if one of the junction is heated, because of the temperature gradient there will be current flow in the circuit. Normally the thermocouple is directly connected to a temperature controller. There are different types of thermocouples depending upon the type of dissimilar metals that are joined together. Thermocouple measures the voltage and convert it into corresponding temperature readings. The voltage measured by the thermocouple is very small and it is in the range of millivolts. In this paper thermocouple of type J is used and whenever temperature in the engine room goes higher than that of threshold value it gives an indication in the HMI.

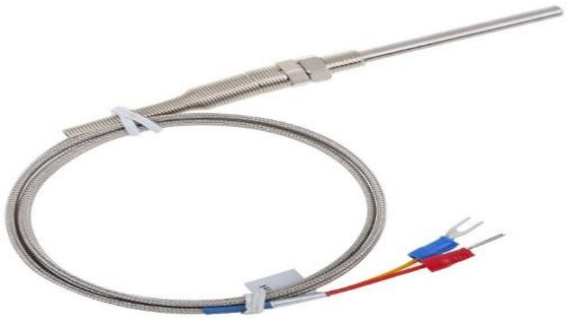

Fig .4: Thermocouple of type J

D. Programmable Logic Controller (PLC)

Programmable logic controller (PLC) is a flexible, reliable and low cost controller widely applied in every industry and mainly used for on-off or logic type applications. It is a special purpose computer capable to control industrial machines or processes and it uses a programmable memory to store instructions such as arithmetic, sequencing, data manipulation, timing and counting. PLC consists of central processing unit, input and output modules, Memory. PLC takes the input conditions which is then stored in the memory. PLC performs programmed logic instructions on the input states and generates the output conditions. This output conditions are then used to drive the associated device. In this project Schneider electric TM200C40R PLC is used with 40 I/O. Ladder programming is used to program the PLC.

IV. SOFTWARE IMPLEMENTATION

A. *So Machine Basic (PLC TM200C40R)*

So machine basic is a unique solution software from Schneider electric used for commissioning, configuring, programming the entire machine in a single software environment.

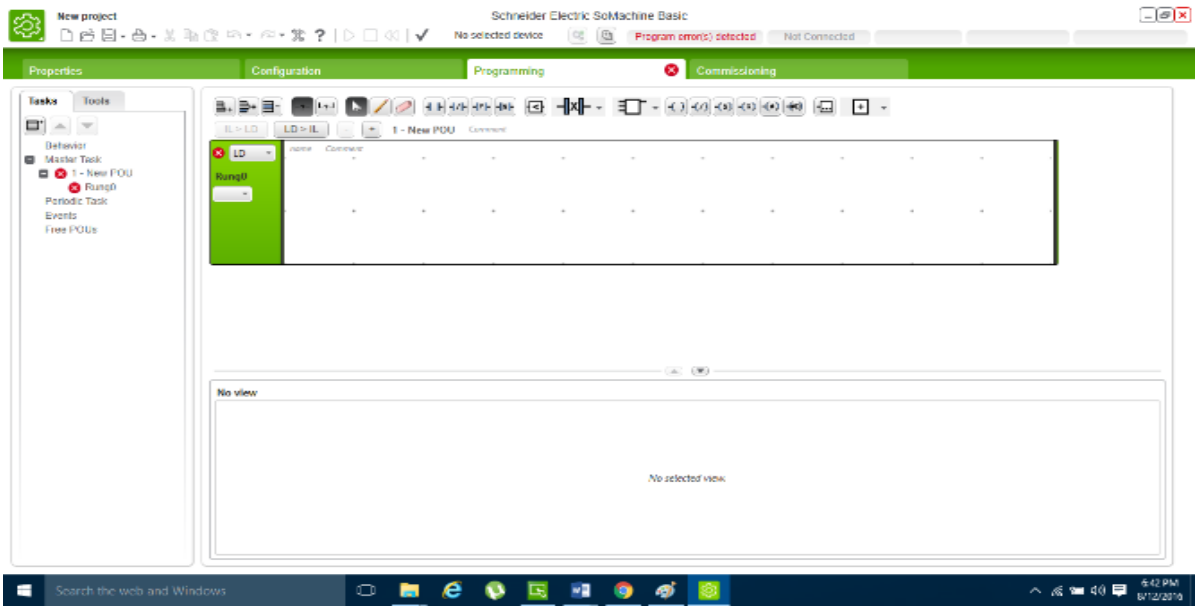

Fig .5: TM200C40R PLC window

2. *Vijeo Designer (HMI GXU3500)*

Vijeo designer is a user-friendly software from Schneider electric dedicated to Magelis HMI configuration.

The functional flow chart of the proposed system in the HMI is shown below. First the user has to enter the password. If the password entered is correct, he can request for access the control room actions. If the iris matches with that of stored, he gets granted access. At the same time detection fire, smoke and high temperature at engine room also detected by corresponding sensors and controller actions is carried out by PLC.

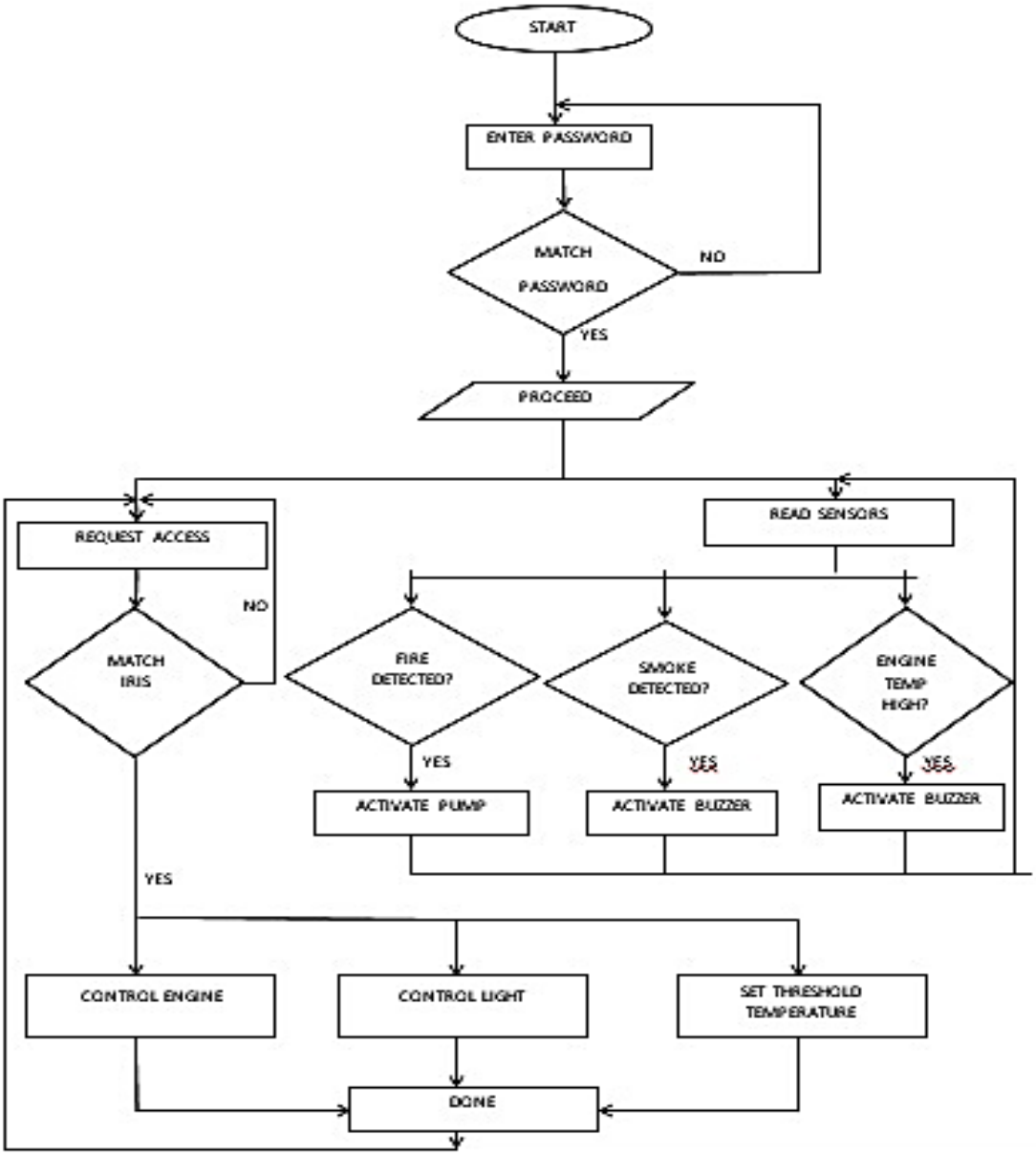

Fig. 6: Functional flowchart of proposed system

V. RESULTS AND DISCUSSION

PLC based control and monitoring system provided good results to ensure safety and security in the ship.

Following are the snapshots captured from HMI of different stages involved in operation.

A) Access - HMI window where the user has to enter the password to gain access

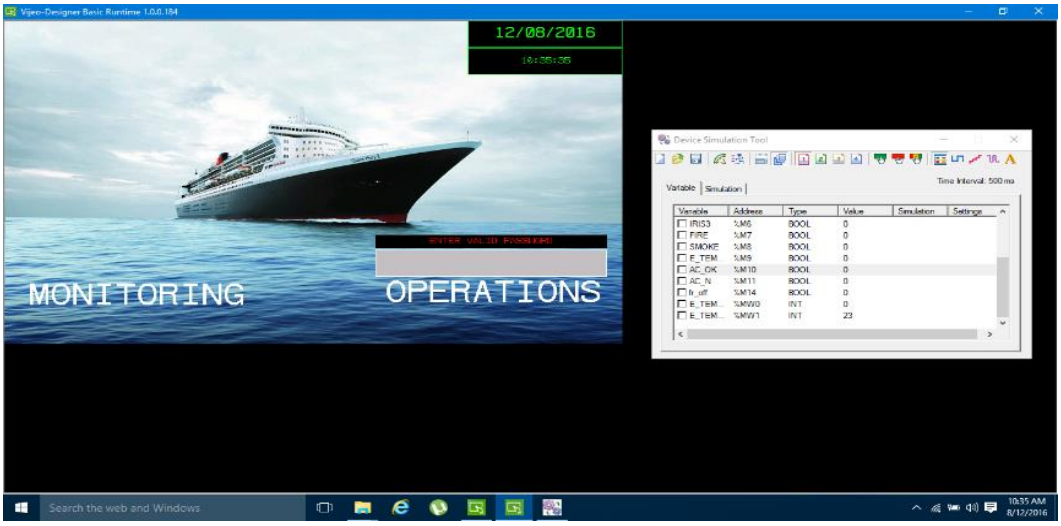

Fig. 7: HMI screen for access

B) Password accepted – Iris recognition window to access control.

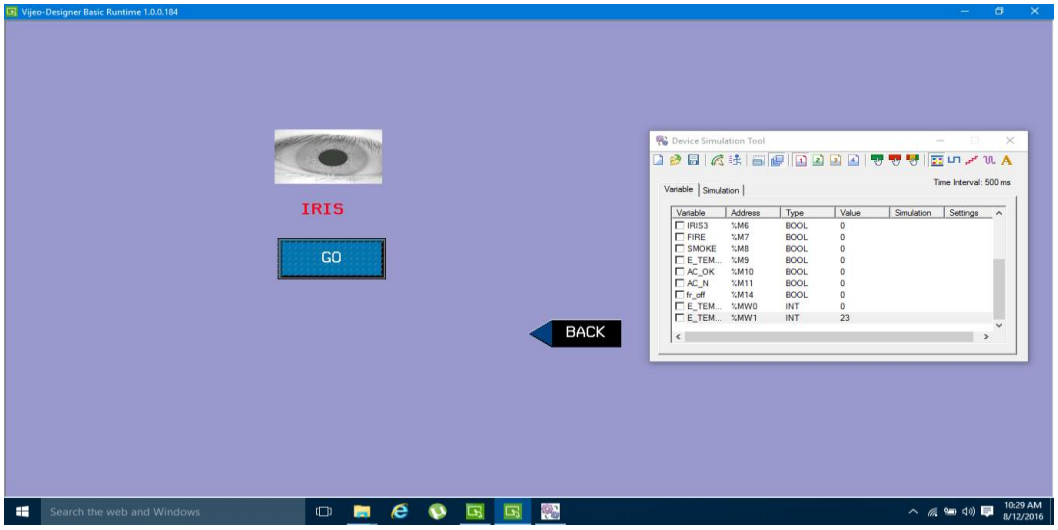

Fig. 8: HMI screen after the password entered is correct

C) Access granted – Iris recognition successful, Iris matched with that stored.

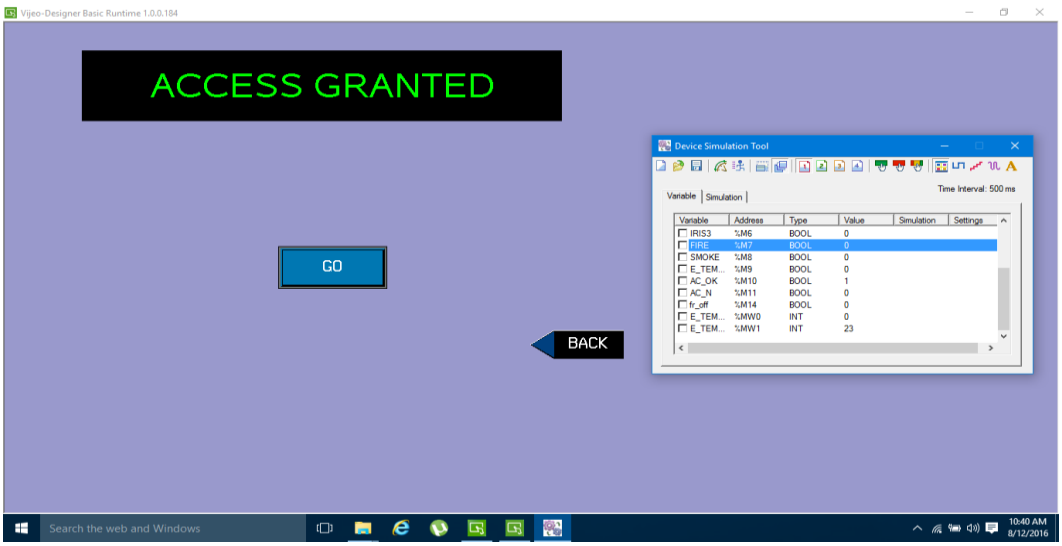

Fig .9: HMI screen after the iris matching

D) Control operations – User can control different operations like Engine Start/Stop, Set threshold temperature, Lights control etc.

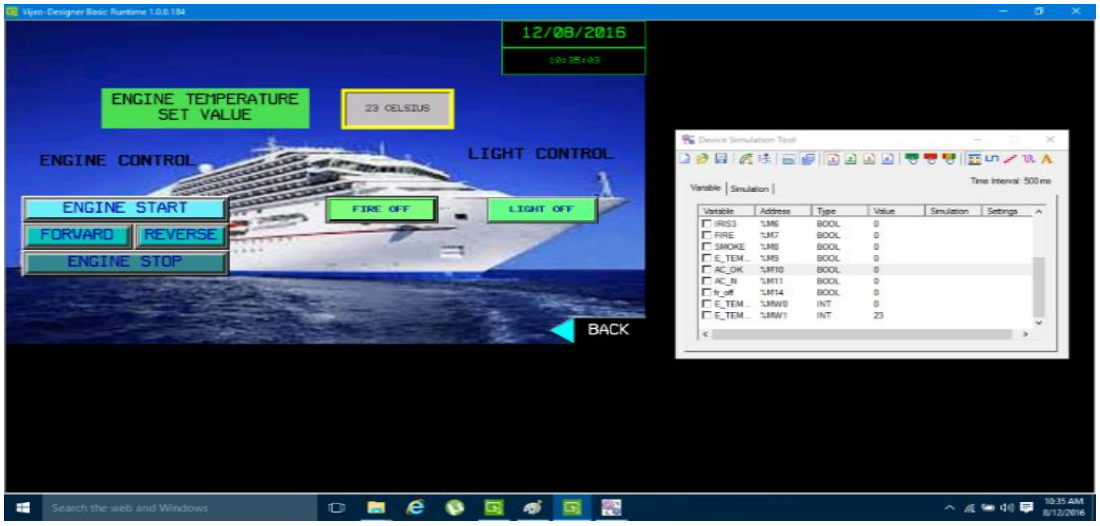

Fig . 10: HMI screen to access the control room actions

E) Access Denied - Iris recognition failed, Iris did not match

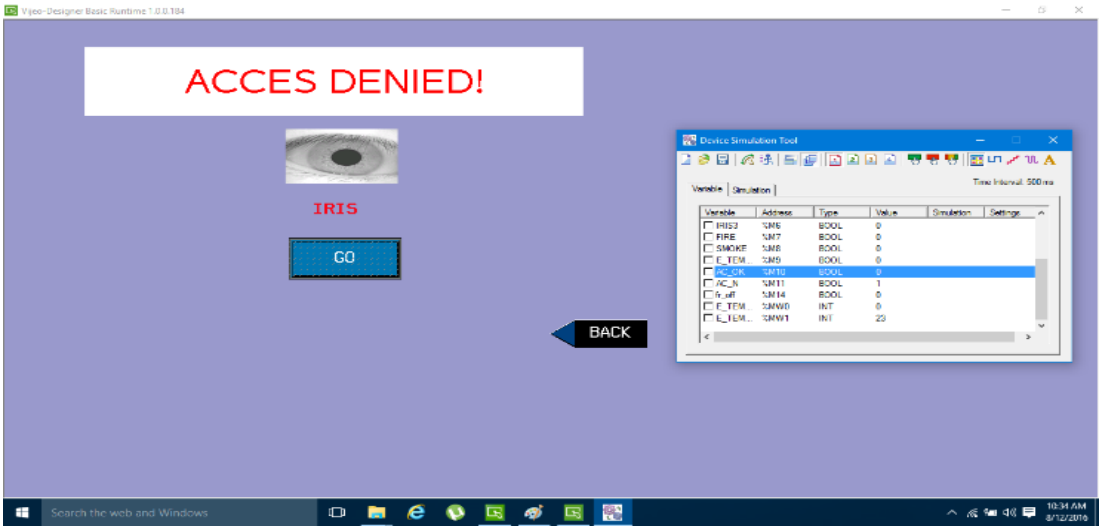

Fig. 11: HMI screen after the iris mismatch

F) Thermocouple detects - Engine room temperature went higher than that of threshold 'HIGH TEMPERATURE'.

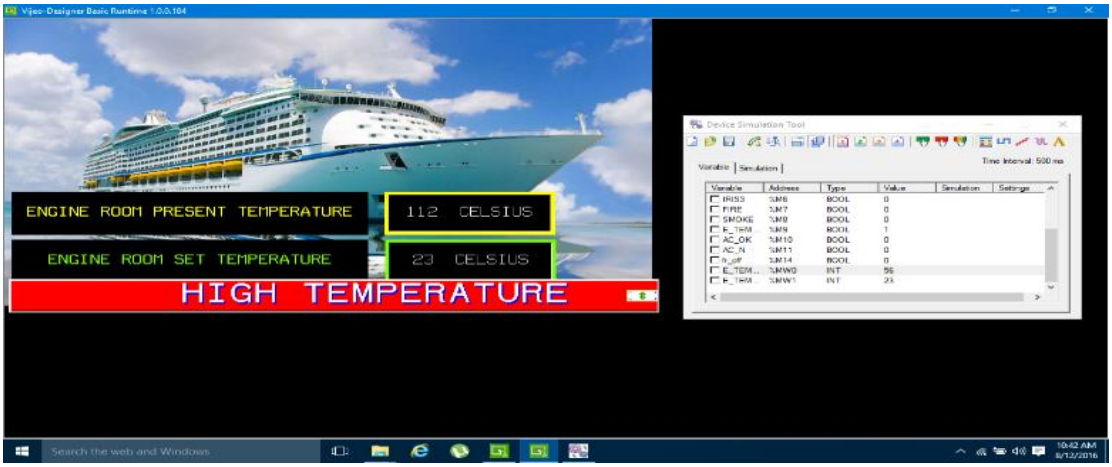

Fig .12: HMI screen if high temperature is detected in engine room

G) Fire sensor activated –HMI gives a warning message 'FIRE DETECTED'.

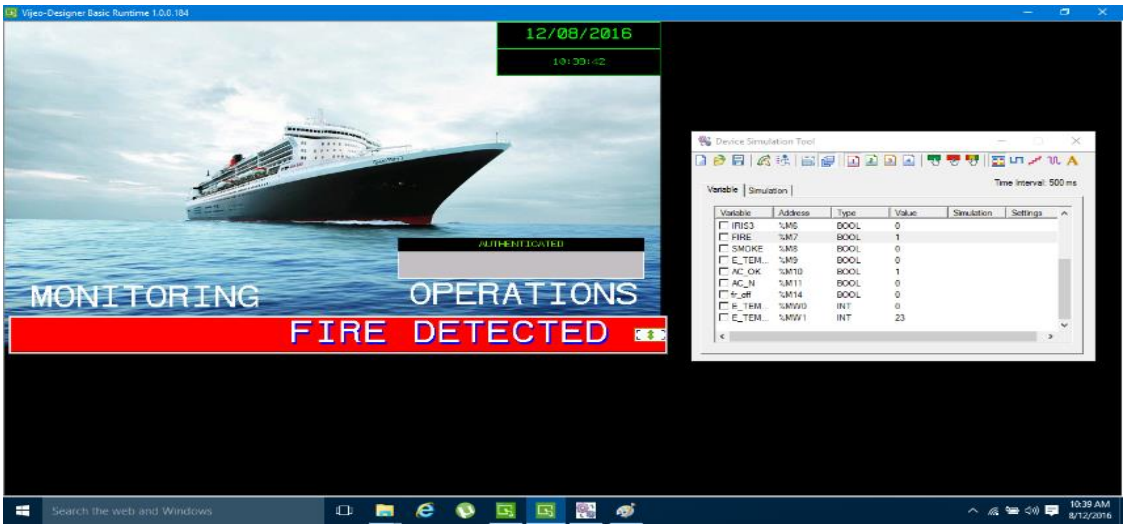

Fig. 13: HMI screen if Fire is detected

VI. CONCLUSION AND FUTURESCOPE

As explained, this automated system ensures a more accurate and reliable solution for early fire detection and security. Fire, smoke and high temperature at engine room are detected by the sensors and necessary control actions are taken using PLC. The system is very user friendly as it displays all the status messages in the HMI. Iris authentication ensures only authenticated people can access the control room actions.

In the project only two parameters are considered, namely fire detection and iris recognition. Many such parameters can also be used to make the system more accurate and more predictive. A cost effective Iris Scanner can be used for capturing real images and authentication.

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