JOURNAL OF MARITIME RESEARCH

Vol XXI. No. II (2024) pp 411–418

ISSN: 1697-4840, www.jmr.unican.es

Development Navigation Light for Tugboat Prototype Based on Arduino

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ARTICLE INFO

Article history:
Received 21 Jan 2024;
in revised from 24 Feb 2023;
accepted 30 Mar 2024.

Keywords:
Navigation, IALA, Tugboat, Arduino.

ABSTRACT

This research aimed to develop a navigation light on the Arduino program as a prototype scale. The method for this research used a prototyping model containing two steps firstly digital model and secondly physical model called a physical prototype. The program of light simulation is based on the Arduino program for some IALA regulations for navigation on tugboat ships. We build a digital 3D model of a tugboat ship with SolidWork software and the result for prototype of a tugboat with navigation lights for seven conditions there are tugboats that are running but not towing or pulling, the tugboat's navigation light is running and is holding or pulling, the tugboat's navigation light is anchored and under quarantine, the tugboat's navigation lights that are running do not tow or tow the barge that is being guided on board, the tugboat's navigation lights that are currently running are towing or pulling the barge that is being guided on board, lights for tugboats entering other countries (immigration), and Lights of a tugboat refueling (bunker). The lamp navigation in ship sign by using a microcontroller for navigation proposed for the practical navigation scenarios.

1. Introduction.

The technology in navigation systems has focused attention on trainers and teaching in maritime education and training. Navigation systems used to prevent a collision which was regulated in the International Regulation for Preventing Collisions at Sea, 1972 of the amendment of 1996 used for the ship and unnamed ship vehicles [1–4]. Navigation pattern is an essential system for the ship on board [5,6] because it communicates between one of the ships to another or between the ship to the port Additionally, a visual sign for the Aid to Navigation (AtoN) conveys specific information useful for various navigation purposes [9,10]. This knowledge is important for signing in the navigation system and it can communicate for preventing an accident between two ships or more [9–12].

IMO has always paid great attention to the improvement of navigational safety [13]. The International Association of Lighthouse Authorities (IALA) is a non-governmental association bringing together services or organizations responsible for the provision or maintenance of lighthouses and other aids to marine navigation [7]. IALA prescribes the lights and markers across the world and implementation of AtoN is special structures for the rule of a lighthouse, lightships, beacons, buoys, etc that are used to enhance the safety line of position the ship [14].

The design of the part navigation light system has predetermined standards and specifications, it needed for navigation and safety in maritime sector [15]. Such as for Maritime Education and Training (MET), the navigation regulations need to teach in the maritime institutions of higher education [16]. The navigation system by STCW Convention is considered required to control and operate simulation for developing knowledge and skill [17]. However, navigation light knowledge in MET still less develop in teaching and problem project-oriented. Additionally, safety aspect and repeatability in the use of tools and teaching process into consideration for this research.

The navigation lights on the ship are used to notify the position, post, and status of the ship and consist of colors light. International conventions or authorities as Collision Regulation

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1972 [19,20] have regulated how the lights are used which the light are mounted on board. The mast or pole on the ship functions as a place of navigational lights and ignite when the dark to notify the direction of the ship rule which are consist of masthead lamp, left and right side lamps, stern lamp or light, towing light, Front-back anchor light or anchor light, and etc.

Tjahjono A et.al [20] found the structure of masthead lights using the finite element method depends on the load of the navigation lights as static loads. The light of navigation lamp for notification and position of the ship with three colors of LED light [21], the prototype by LED design navigation lighting system [22]. Another navigation field for the loading cargo on the ship with real-time monitoring equipment requirements based on the technology of the OpenCV library [23] and need to implement for the autonomous ship [25–30]. These researchers have found navigation lights in the ships for structure and regulation of AtoN essential to enhance safety and assessment, but they're not have implemented for navigation light-based microcontroller systems. Using microcontroller system for navigation light this research is to suitability and safety of teaching and learning process compared to learning activities on a ship which are more dangerous.

Arduino Uno is a microcontroller board (Attribution - ShareAlike 3.0 Unported (CC BY-SA 3.0) that is based on the ATmega328 series controllers, and has an integrated development environment (IDE) for writing, compiling, and uploading codes to the microcontroller [31,32]. For modifications to the navigation lights various vessels specialized by and large users of the sea are now clearly and distinctively lighted by night. For sailing vessels require the development of navigation lights to display at the night [32]. This research develops the prototype of the masthead light of a tugboat with the Arduino Uno for controlling the lamp light switch on and simulating the navigation light.

2. Methods.

This research uses the prototyping project [33] with two steps firstly modeling the prototype with software-based computerizing said as digital model and secondly building the prototype with laboratory scale said as physical model [34]. Here we do the digital models with 3D drawing of the tugboat ship for representation, creation, and modification of real projects and the physical prototypes are comparable digital models of complicated or large-capacity forms.

3. Results And Discussion.

In the tugboat, the navigation light has an essential luminaire for sailing even for autonomous tugboat [35]. For this research, we classified the masthead light, side light, towing light, stern light, immigration, and bunker. We used the white LED light for the masthead light to inform the situation and location of others. Sidelight the red and green LED we used to inform a direction to sail like a turn signal. Both are installed on the left side with a red light and on the opposite side with a green light. Also, for towing light we used white LED light is used to inform a situation in tow. The digital model built by SolidWorks represents the 3D drawing of a tugboat but the light simulation from this model does not work as fig.2. The physical model a prototype as Fig 3. This model built is a laboratory scale. The lamp composed of color LED are white, red, and green.

Figure 1: Tugboat 3D model.

Source: Authors.

Programming on Arduino is done using the Arduino 1.8.16 application which is downloaded from https://www.arduino.cc-/en/software which is free to download. Through the Arduino 1.8.16 application, the authors compiled the program as shown in Fig 4. Several applications of light rules on ship navigation specifically for tugboats. Code input on the page the verify and upload the programming language.

Figure 2: Physical prototype of tugboat.

Source: Authors.

Navigation lights are installed and equipped to operate continuously from dawn till dusk. For the duration of the trip, it was pitch black. As necessary, navigational shapes must be made available for daylight navigation. The attention in simulation of navigation most important to receive a realistic situation accurately [36]. Because the competencies for navigation skills are required for seafarers by The STCW [37].

This prototype tugboat and navigation lights were designed for learning simulation. This tool developed in the laboratory scale for learning and training process.

Figure 3: The tugboat does not tow while running.

Source: Authors.

```
int maskheadWhite = 5;
int sideleftRedGreen = 9;

void setup() {
pinMode(maskheadWhite, OUTPUT);
pinMode(maskheadWhite, OUTPUT);
}

void loop() {
digitalWrite(maskheadWhite, HIGH);
digitalWrite(sideleftRedGreen, HIGH);
}
```

In this project in figure 3, we set the LED light of a mask head switch on, and the two LED lights on the left side green color and the right red color switch on. The LEDs are connected to digital pins 5 and 9. The towing LED is connected to digital pin 5 and the side LEDs green and red color are connected to pin 9.

The Program statement was written in a HIGH or a LOW value to the digital pin within the statement (in this case "maskheadWhite" and "sideleftRedGreen", which are Digital Pins 5 and 9). We set a digital pin to HIGH which means we are sending out 5 volts to that pin. So, the voltage of 5v sends out to the LED from digital pins 5 and 9 then turns the LED on.

In this project in figure 5, we set the LED light of a mask head switch off, and the two LED lights on the left side green color and the right red color switch on, and three towing LEDs switch on The LEDs are connected to digital pins 12, 11, 10, 9 and 5. The towing LED is connected to digital pin 5 and the side LEDs green and red color are connected to pin 9. While the towing LEDs are connected to digital pins 12, 11, 10.

The Program statement was written in a HIGH or a LOW value to the digital pin within the statement (in this case "towing1White", "towing2White", "towing3White", "sideleftRedGreen" and "maskheadWhite", which are Digital Pins 12, 11, 10, 9 and 5). We set a digital pin to HIGH which means we are sending out 5 volts to that pin. When we set it to LOW the pin becomes 0 volts, or Ground. So, the voltage of 5v sends out to the LEDs from digital pins 12, 11, 10, and 9 then turns the LEDs on. Meanwhile, we set to switch off the "maskheadWhite" LED.

Figure 4: The tugboat towing while running.

Source: Authors.

```
int towing1White = 12;
int towing1White = 11;
int towing1White = 10;
int sideleftRedGreen = 9;
int maskheadWhite = 5;

void setup() {
pinMode(towing1White, OUTPUT);
pinMode(towing2White, OUTPUT);
pinMode(towing3White, OUTPUT);
pinMode(sideleftRedGreen, OUTPUT);
pinMode(maskheadWhite, OUTPUT);
}

void loop() {
digitalWrite(towing1White, HIGH);
digitalWrite(towing2White, HIGH);
digitalWrite(towing3White, HIGH);
digitalWrite(sideleftRedGreen, HIGH);
digitalWrite(maskheadWhite, LOW);
}
```

Figure 5: The tugboat anchored and under quarantine.

Source: Authors.

```
int towing1White = 12;
int towing1White = 11;
int towing1White = 10;
int sideleftRedGreen = 9;
int maskheadWhite = 5;
int bunker1Red = 4;
int commadWhite = 2;

void setup() {
pinMode(towing1White, OUTPUT);
pinMode(towing2White, OUTPUT);
pinMode(towing3White, OUTPUT);
pinMode(sideleftRedGreen, OUTPUT);
pinMode(maskheadWhite, OUTPUT);
pinMode(commadWhite, OUTPUT);
pinMode(bunker1Red, OUTPUT);
}

void loop() {
digitalWrite(maskheadWhite, HIGH);
digitalWrite(bunker1Red, HIGH);
digitalWrite(commadWhite, HIGH);
digitalWrite(towing1White, LOW);
digitalWrite(towing2White, LOW);
digitalWrite(towing3White, LOW);
digitalWrite(sideleftRedGreen, LOW);
}
```

In this project in figure 5, we set the LED light of a mask head switch on, and the two LED lights on the left side green color and the right red color switch off, three towing LEDs switch off, then for the bunker LED and commad LED are switch on. LEDs are connected to digital pins 12, 11, 10, 9, 5, 4 and 2. The towing LED is connected to digital pin 5 and the side LEDs green and red color are connected to pin 9. The towing LEDs are connected to digital pins 12, 11, 10. For the bunker1Red LED connected to digital pin 4 and commadWhite LED connected to digital pin 2.

The Program statement was written in a HIGH for the maskhead LED, bunker LED and commad LED. Meanwhile, a LOW for 3 LEDs value are towing1White, towing2White, towing3White, and sideleftRedGreen.

Figure 6: The tugboat does not tow while running and being guided.

Source: Authors.

```
int sideleftRedGreen = 9;

int maskheadWhite = 5;

int bunker2Red = 3;

int commadWhite = 2;

void setup() {

pinMode(sideleftRedGreen, OUTPUT);

pinMode(maskheadWhite, OUTPUT);

pinMode(commadWhite, OUTPUT);

pinMode(bunker2Red, OUTPUT);

}

void loop() {

digitalWrite(maskheadWhite, HIGH);

digitalWrite(sideleftRedGreen, LOW);

digitalWrite(bunker2Red, HIGH);

digitalWrite(commadWhite, HIGH);

}
```

Figure 7: The tugboat towing while running and being guided.

Source: Authors.

```
int towing1White = 12;
int towing1White = 11;
int towing1White = 10;
int sideleftRedGreen = 9;
int maskheadWhite = 5;
int bunker2Red = 3;
int commadWhite = 2;

void setup() {
pinMode(towing1White, OUTPUT);
pinMode(towing2White, OUTPUT);
pinMode(towing3White, OUTPUT);
pinMode(sideleftRedGreen, OUTPUT);
pinMode(maskheadWhite, OUTPUT);
pinMode(commadWhite, OUTPUT);
pinMode(bunker2Red, OUTPUT);
}

void loop() {
digitalWrite(towing1White, HIGH);
digitalWrite(towing2White, HIGH);
digitalWrite(towing3White, HIGH);
digitalWrite(sideleftRedGreen, HIGH);
digitalWrite(bunker2Red, HIGH);
digitalWrite(commadWhite, HIGH);
digitalWrite(maskheadWhite, LOW);
}
```

Figure 8: The tugboat in immigration.

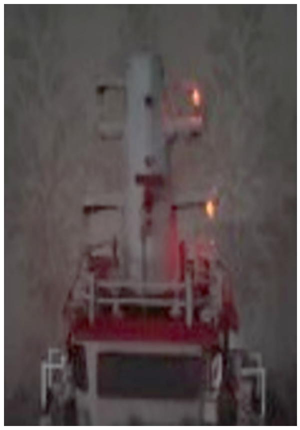
Source: Authors.

```
int imigrasi1Green = 7;
int imigrasi1Green = 6;
int sideleftRedGreen = 9;
int maskheadWhite = 5;
int bunker2Red = 3;
int commadWhite = 2;

void setup() {
pinMode(imigrasi1Green, OUTPUT);
pinMode(imigrasi2Green, OUTPUT);
pinMode(sideleftRedGreen, OUTPUT);
pinMode(maskheadWhite, OUTPUT);
pinMode(commadWhite, OUTPUT);
pinMode(bunker2Red, OUTPUT);
}

void loop() {
digitalWrite(imigrasi1Green, HIGH);
digitalWrite(imigrasi2Green, HIGH);
digitalWrite(sideleftRedGreen, LOW);
digitalWrite(bunker2Red, LOW);
digitalWrite(commadWhite, LOW);
digitalWrite(maskheadWhite, LOW);
}
```

Figure 9: The tugboat is refueling (bunker).



Source: Authors.

```
int imigrasi1Green = 7;
int imigrasi1Green = 6;
int bunker1Red = 4;
int bunker2Red = 3;

void setup() {
pinMode(imigrasi1Green, OUTPUT);
pinMode(imigrasi2Green, OUTPUT);
pinMode(bunker1Red, OUTPUT);
pinMode(bunker2Red, OUTPUT);
}

void loop() {
digitalWrite(bunker1Red, HIGH);
digitalWrite(bunker2Red, HIGH);
digitalWrite(imigrasi1Green, LOW);
digitalWrite(imigrasi2Green, LOW);
}
```

The design will be refined if there are still deficiencies according to the applicable IALA rules [38]. We need verification and validation next to implement the prototype requirement. Independently powered navigation lights are required, and the gasoline or power supply must be sufficient with reserve for the towage's maximum duration.

The "Manila Amendments" to the current Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) and its associated Code were approved by the International Maritime Organization (IMO) and other significant players in the global shipping and manning industry [39]. The 1995 SOLAS revision state **the Regulation 10-1**: Master's discretion for safe navigation. The regulation [40], which was adopted in 1995 and entered into force on 1 July 1997, states that the master of ship shall not be constrained by the ship owner, charterer or any other person from taking any decision necessary for safe navigation, particularly in severe weather and heavy seas. While the **Regulation 11**: Signalling lamps: All ships of over 150 gross tonnage engaged on international voyages are required to be provided with a signalling lamp [41].

Achieving an efficient learning process for a ship light sign simulation uses a microcontroller-based solution to execute real-time activities on devices with constrained memory and processing power. We operated the lamp navigation in ship sign by using a microcontroller for navigation proposed as our focus for the practical navigation scenarios.

Conclusions.

We developed the navigation light for tugboat prototype based on Arduino. a digital 3D model of a tugboat ship by SolidWork software. Result of navigation light prototype of a tugboat for seven conditions there are tugboats that are running but not towing or pulling (not towing), The tugboat's navigation light is running and is holding or pulling (while towing), The tugboat's navigation light is anchored and under quarantine, The tugboat's navigation lights that are running do not tow or tow the barge (not towing) that is being guided (the guide is on board). The tugboat's navigation lights that are currently running are towing or pulling the barge (towing) that is being guided (the guide is on board). Lights for tugboats entering other countries (immigration), and Lights of a tugboat refueling (bunker). The lamp navigation in ship sign by using a microcontroller for navigation proposed for the practical navigation scenarios.

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