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SWARM ROBOTICS SYSTEM FOR HOSPITAL MANAGEMENT

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Abstract: In these unprecedented times where the whole world is battling against a deadly virus, it's our health care workers who are fighting hard to control the spread and help the patients to overcome this disease. Hence, they are at a high risk of getting infected due to the close interaction with the infected patients. As a solution to the above-mentioned situation, we propose an idea to efficiently manage the hospital requirements by introducing swarm robotics thereby, minimizing the probability of the health workers subjected to the risk of getting infected. Using the swarm robotics concept, multiple tasks such as biomedical waste management, cleaning of the floors can be achieved simultaneously, which eliminates the chance of being in contact with the infected patients. Biomedical waste management involves the automatic collection of waste without any human intervention and further disinfecting them. This eliminates the spread which otherwise would happen when people come in contact with these waste materials which may contain the pathogen of the disease. The swarm concept comprises of a transmitter that assigns different tasks to several bots at the required time of need with the help of LoRaWAN Technology. These bots act according to the signal received from the transmitter and moves to the area of interest using the Indoor Positioning System to collect the bio-waste and carry out the disinfection process. All the bots are housed with an automatic disinfecting bin and have a cleaning system attached to it, which performs the cleaning task. The idea behind this project is to provide complete automation in hospital management and to reduce the spread of infection by introducing Swarm robotics into the field.

Index Terms – Swarm Robotics, LoRaWAN, Indoor Positioning System

I. INTRODUCTION

The health sector is one of the most important sectors in every country. Now the whole world is going through a tough time after the outbreak of covid-19, and it poses a challenge for this health sector. On the 30th of January, 2020 COVID19 Pandemic was publicly announced as one of the "global emergencies", by the World Health Organization (WHO) because of the rapidity at which it had spread worldwide. There are so many problems the health sector is facing after the occurrence of this situation.

During these troubled times, we find the health workers fighting hard to overcome this covid-19 disease without giving a thought about their safety in the effort to save their patients. As we know COVID-19 is one of the dangerous contagious diseases, so a healthy person coming in contact with an affected person can easily be attacked by this virus. Health workers are the most exposed to these Covid-19 patients, so their probability to get infected is high. The cleaning staff, who collects the garbage are also very much prone to get infected as the waste materials like injections, cotton, etc. may contain the pathogen of the disease and this may spread to the health workers too. Also, due to poor facilities, lack of training, and unhealthy working conditions, increases the exposure of a part of health workers to this disease [1]. So, it is very important to take an advanced measure so that these hospital staffs are safe, we can effectively manage this situation by using technology- the most powerful tool we have with us.

The present researches are intended to highlight the importance of medical robotics and how its utilization can help in the management of the COVID-19 pandemic. By doing so, the hospital management can direct their efforts towards maximizing the use of medical robots for various medical procedures. At present, several robots have been deployed such as mobile robots for cleaning and human services [2], and some static robot arms for wiping and treatment purposes [3]. It is predicted by the International Federation of Robots (IFR) that, there will be a shoot in the trend for the demand for medical robots in the coming years, which is estimated to be around 9.1 billion USD market by the year 2022. The use of robots for medicine and food delivery for patients [4] is also being a topic of discussion in the present situation. Thus lower the workload of medical staff and physicians, better the efficiency of the healthcare facilities.

We are also introducing such a system that will help these health workers to stay safe and decrease their workload. There have been many Socio-cultural, economic impact, health, and National healthcare challenges faced by this world during this pandemic condition, but here we are concentrating on the challenges faced by health sector workers like biomedical waste management and cleaning, as there are multiple ways in which biomedical waste can be handled scientifically [5] and also maintain a hygienic environment. Swarm robotic systems can be used in hospital management. The framework of the paper has Section 2 which gives a brief introduction to the related work. Section 3 includes the overall model of the proposed system. Section 4 explains the working of the model. The experimental results and observations are shown in Section 5. Section 6 concludes the paper with directions for future work.

II. LITERATURE SURVEY

Swarm robotics is an emerging field that is gaining profound importance these days. Many applications can be implemented effectively using this field.

A lot of researches are being carried out to get a better understanding and knowledge of how swarm robot's work. In [6] the swarming and herding behaviour of the swarm robots are analyzed using simple robots. It demonstrates the application of artificial intelligence (AI) in the robotics field. This can then be modified to meet the demands of the industry and to enhance the automation sector. Every single robot is incorporated with 8-bit microcontrollers which are economical, are used as its brain in a swarm environment. Though, robots that are a part of a system works individually. It starts from a location and all gathers to a location. A semi-consistent swarming behaviour is achieved by using simple circuit designs and readily available microcontrollers. Using AI algorithms these robots will reach various locations even if they will not be following a predefined path.

An earlier development in the hospital field that gained attention was Swisslog RoboCourier. As in the paper [7], the salient features of this robot are complete revamp for better functionality and efficacy. It highlights the software along with various applications in the medical industry. Using Swisslog Robocourier hospitals can be fully automated, medicines, and laboratory equipment. It will change the scenario in the hospitals by saving the time of technicians and processing units. By installing this, technicians can transport their samples using automation enabling them to serve the patients. It can be recharged from a standard wall outlet.

Waste management is one of the major problems faced in the current situation. The present waste management system is expensive and inefficient. The recycling process has failed to prove its effectiveness in society and recycling the waste has become a major concern. Nowadays, there are better alternatives in technology like the Internet of Things (IoT) and AI. One of the smart and efficient alternatives is to replace the existing methods of waste management with sensors that can be incorporated into the system as discussed in [8]. This system makes use of the LoRaWAN, a communication-based protocol used to effectively manage waste. LoRa is used for sending the sensor information. TensorFlow has machine learning libraries that detect and classifies the object in real-time.

The bin is divided into several layers to do different functions like collecting metals waste, unwanted plastic waste, pieces of paper, etc. These compartments are managed by the servo motors. The TensorFlow framework performs object detection and classification which is achieved with the help of a training phase. Here the input to the model is the images of waste. These images are converted to a graphical representation. This is achieved by connecting a camera. The heart of the model is the Raspberry Pi 3 Model B+. The filling level of each compartment is monitored using an ultrasonic sensor which is present in each section. A Global Positioning System is used in this system to obtain the present location of the bin. LoRa transmits data such as the position of the bin, and the capacity of the bin. Waste management personnel identification is also carried out by the RF module embedded inside it.

Recently there is a surge in innovative cleaning bots. Cleaning that is of prime importance to sustain a healthy environment is seen to be neglected often. In [10] the authors propose an automatic cleaning robot that is designed to perform all cleaning activities without any human intervention. This robot performs the function of floor mapping, and dry vacuum cleaning. The dirt is gathered along the movement of the machine. This, is done with the help of spinning brushes attached at the lower portion of the machine. The movements of these bots are achieved by certain algorithms. These algorithms plan the path of interest and helps the machine to navigate accordingly. Obstacle detection is carried out by the sensors embedded in it. When the machine realizes its battery level is low, the robot will go to its docking station and get charged. Once it's fully charged the robot resumes its cleaning process.

A more efficient model that combines all the above functions can be developed by applying swarm robotics. Our model here efficiently collects waste and disinfects it further and also cleans the surroundings by acting upon the signals received by them. By comparing the existing methods adopted for hospital management, it is evident that incorporating swarm robotics for carrying out various needs of the hospitals will prove to be more efficient since multiple services can be done without any human intervention.

III. WORKING OF THE PROPOSED SYSTEM

The system constitutes of a transmitter that initiates the process. The transmitter has the task of sending the signal to the other bots at the required time of need with the help of LoRaWAN Technology [11]. Upon receiving these signals, the bot starts moving towards the area of interest using an Indoor Positioning System that helps in detecting the accurate position of the collection point and also moves accordingly by checking whether there is any obstacle on the way [9]. As shown in Fig 1, a box is housed on the bot that collects the biomedical waste like masks, gloves, etc, and performs a series of operations to disinfect the materials. The bot also has a cleaning system as shown in Fig 3, that is attached to it to carry out the cleaning when needed. The bin that is housed on top of the bot is divided into two stages as shown in Fig 2, where at the first stage, there is an IR sensor that detects the quantity of waste collected, and these wastes are sterilized by spraying sanitizer. This sterilized waste is flipped into the next stage after a stipulated time. In the second stage of the bin, the waste materials are further treated using UV light. Finally, the disinfected waste materials can be collected from the drawer arrangement that is provided at the bottom of the bin. The bot [12] goes to the waste collection points to collect the waste. Upon reaching the collection point, the stationary bin at the collection point senses the commencement of the bot and flips open the lid which is at the bottom part of the stationary bin. This transfers all the collected waste into the automatic disinfecting bin housed above the bot which would now be below the main bin as shown in Fig 1.

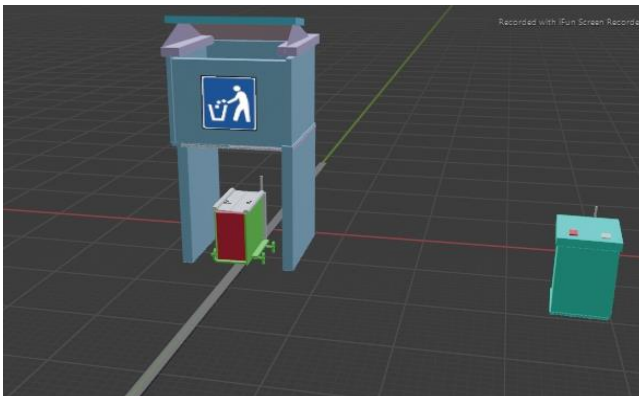

Fig.1. Pictorial Representation of the Proposed System

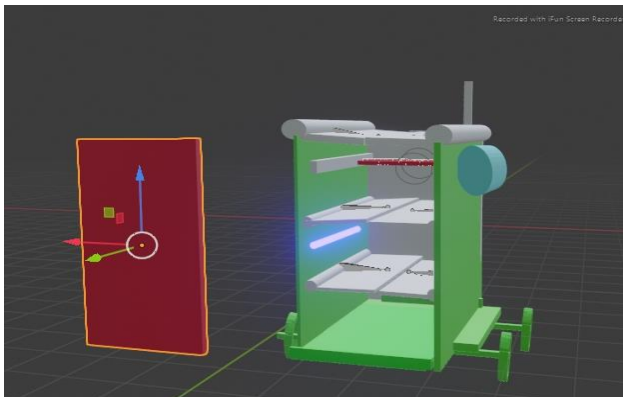

Fig.2. Internal View of the Disinfecting Bin

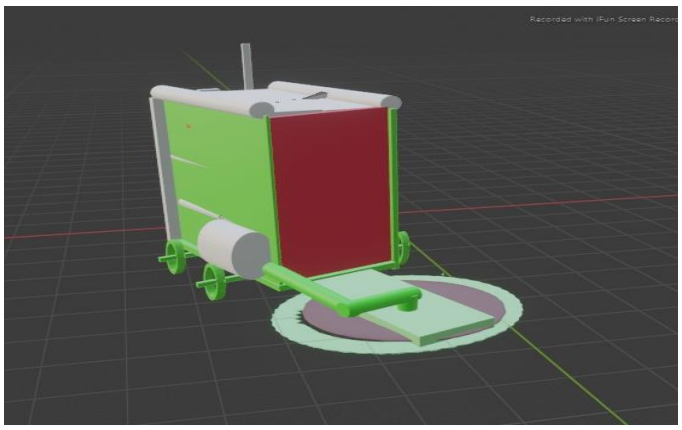

Fig.3. Structure of the Bot

Simultaneously when the transmitter sends signal for cleaning, the bot carries out the cleaning with the help of cleaning arrangement attached to it. The cleaning structure cleans the floor along with the movement of the vehicle. Many bots perform this same function at different places simultaneously. We need not have to provide different controls for these, thus making the cleaning process a more simple and well-coordinated one. By adopting this method, the hospitals will be able to efficiently carry out different tasks simultaneously without any human intervention.

IV. BLOCK DIAGRAM AND EXPLANATION

This is a swarm robotic system that would help in the hospital management. This system constitutes of a transmitter section and several mobile bots. LoRa transceiver are incorporated in this to establish communication between them and the slaves work as per the transmitted signal. Block diagrams of the proposed swam robotic system is as follows:

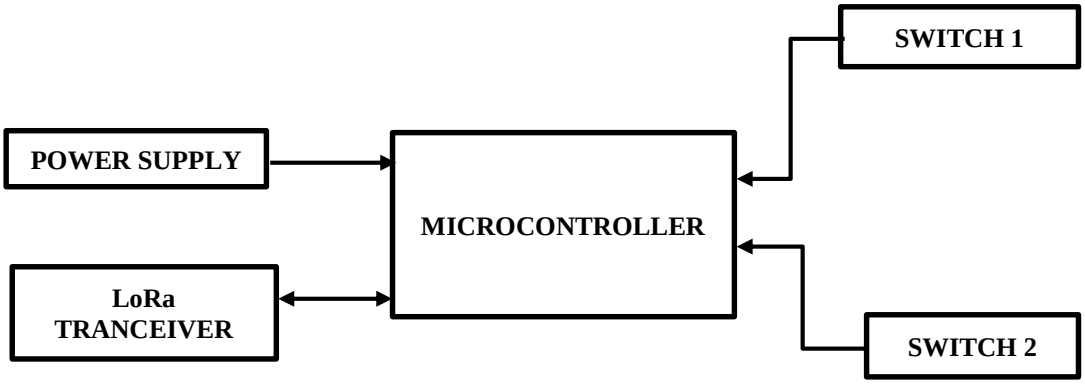

Fig.4. Transmitter Section

4.1 Transmitter Section

The transmitter section consists of a microcontroller which is powered by a power supply. The LoRa Transceiver module establishes the communication between itself and the bot. At the required time of need for given function the switch initiates the microcontroller to transmit the signal via the transceiver. Switch 1 indicates the need for waste collection and disinfection. Switch 2 indicates the need for cleaning.

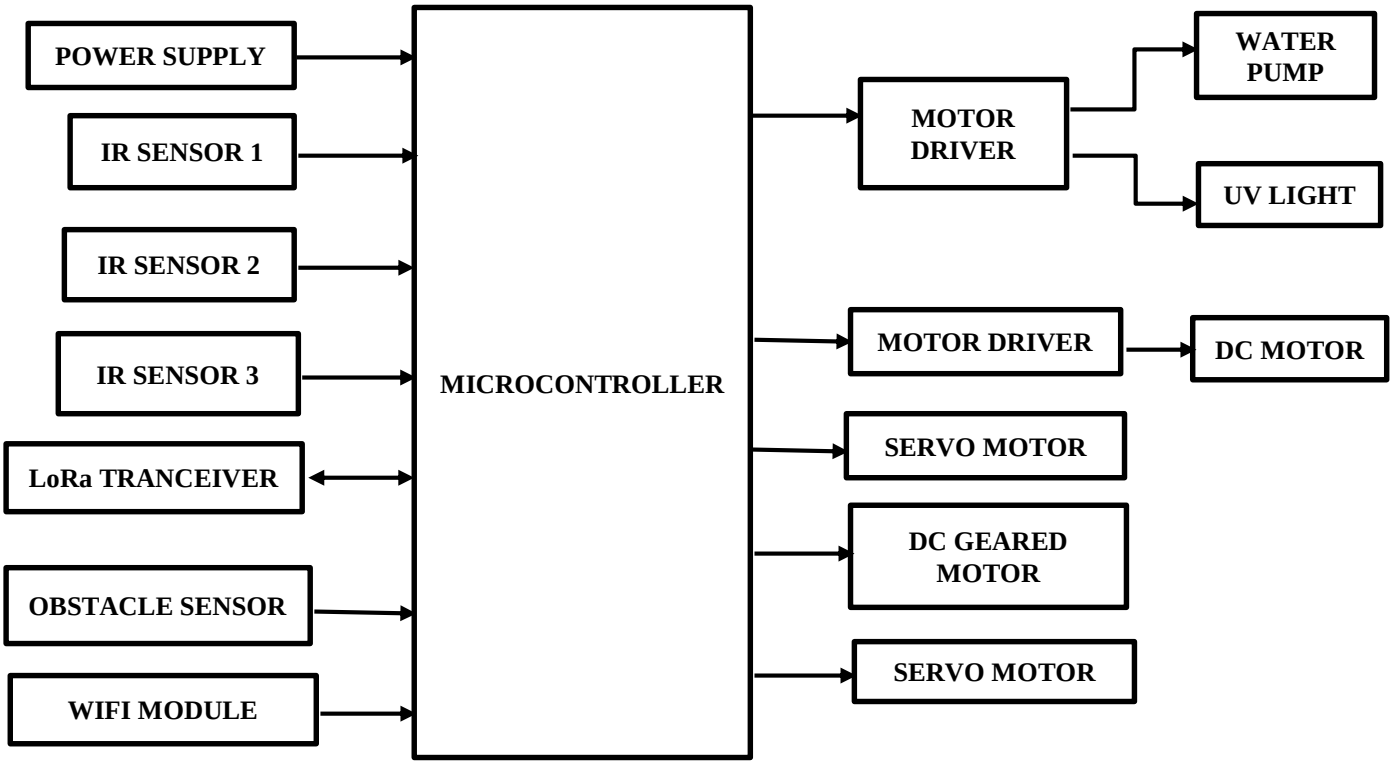

Fig.5. Block Diagram of Mobile Bot

4.2 Bot Movement

The mobile bot structure has been shown in Fig.7. To enable the movement of the bot, dc motors with a motor driver is connected to the tires. When the signal for the execution of a task is received from the stationary transmitter section the bot head towards its destination. There is a LoRa transceiver module for receiving the signals sent by the transmitter section. The Indoor positioning system is used to know the destination. An obstacle sensor is present to sense the obstacles in the way which makes the locomotion of the bot hurdle free. All these arrangements are kept above a strong case.

4.3 Waste Collection and Disinfecting

After reaching below the main bin IR sensor is made low. Then servo motor helps to open the lid of the waste bin which is housed above the bot and also the sanitization of the hospital waste. Sanitization is done with the help of a 12V dc motor immersed in the sanitizer and a tube attached with a nozzle. Another servo motor is used to flip the division so that waste is sent to the next stage of disinfection, which is UV light treatment. The partition flips only when a particular level is reached and this is known by placing an IR sensor. L293 motor driver gives the input for the dc motor and the UV light. In the end the disinfected materials reach the bottom draw of the bin from where it can be removed and discarded by the staff safely. Along with this an IR sensor has been incorporated into this system that makes the led to turn on indicating the filling level of the bin. When this happens, the bot is programmed such that it goes to the transmitter. And once the treated wastes are removed it restarts its function.

4.4 Cleaning Structure

A 360-degree rotating mop is attached to a geared dc motor which facilitates the cleaning action. There is also a roller associated with it for its working we are providing a servo motor. This cleaning is done in accordance with the Wi-Fi positioning system. A small water container and a water pump is also kept so that water can be sprayed to the floor thus cleaning can be done properly and efficiently. This whole arrangement is shown in Fig 5.

4.5 Stationary Bin Mechanism

Fig. 6. represents the stationary waste-collecting bin which comprises of a microcontroller. This microcontroller is powered using a 5V power supply. The IR sensor attached to it sends a signal to the microcontroller when it senses the bot. The microcontroller in response to the sensor deploys the servo motor to run. Thus, the waste collected is transferred to the disinfecting bin as shown in Fig 6. which is housed on the bot.

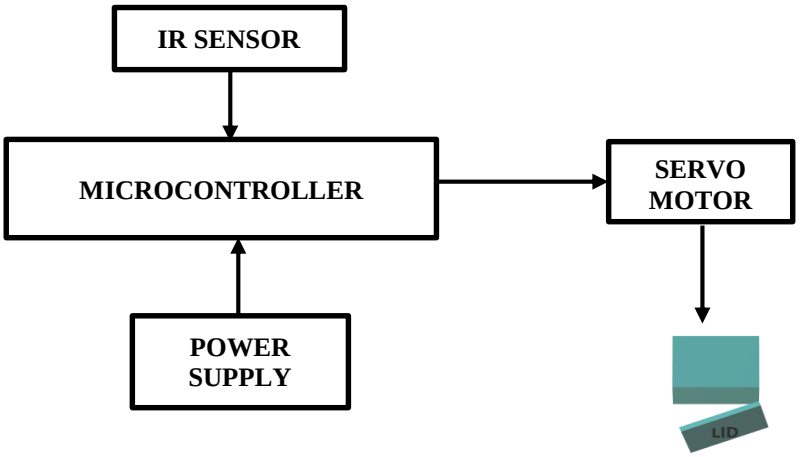

Fig.6. Block Diagram of Stationary Bin

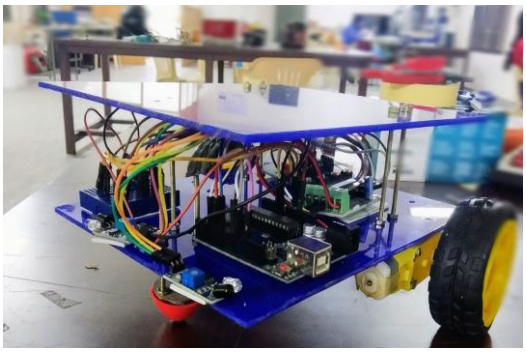

Fig.7. Structure of the Bot

V. RESULTS AND DISCUSSION

A transmitter section and three bot were constructed as shown in Fig 8, and the communication link were established among them using LoRa communication protocol for transferring commands. The location of the Stationary bin was detected by the bot by using the Indoor Positioning System successfully. While the instructions were given for waste management, the bots reached their target area which is under the stationary waste bin. After detecting its presence lids of both the bins were opened and the waste inside the main bin was automatically transferred into the automatic disinfecting bin that was housed above the bot. The first layer of the bin sprayed the sanitizer for 30 seconds. Soon after that, the partition inside the bin flipped, transferring the preliminary disinfected materials to the second stage where it was further disinfected by UV treatment. After these treatments, the processed materials were collected at the bottom draw. After going through all the collection points these bots reached at their destination. Meanwhile, the treated wastes were removed from the draw. Along with its movement, the rotating mops attached to these bots simultaneously cleans the floor.

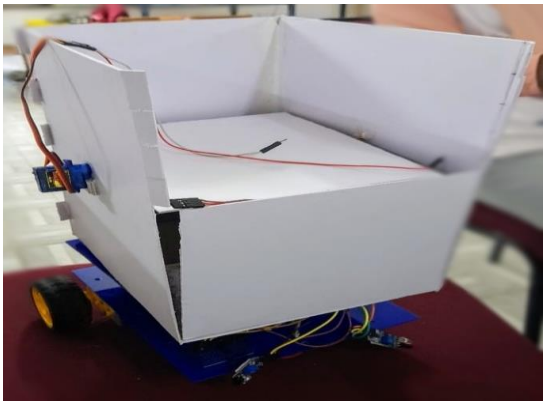

Fig.8. Overall Structure of the Bot

VI. CONCLUSION AND FUTURE SCOPE

By introducing these swarm robots into hospitals, we hope that it will result in minimizing the life threat to medical staff and the doctors who play an active role in containing the COVID-19 pandemic. As we know this pandemic could be defeated only by creating a clean and hygienic environment for the people. By introducing this product the aim is to provide a similar environment in the hospitals, by automatic garbage collection, disinfection and cleaning. This product would also make the work of the hospital staff comfortable and easy. This product will be an advancement in both swarm robotics as well as in automated hospital management systems. This is a product with a very good market value, as it's the need of the coming ages. This project can be extended by incorporating more functionalities to this system like medicine delivery by attaching an arm-like structure and can be also used as an assistant in surgeries.

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