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Cancer Detecting Nanobot using Positron Emission Tomography

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Abstract

The current Indian population is 1.29 billion out of which the occurrence of cancer is estimated to be around 2.6 million with over 9,00,000 new cancer patient and 6,50,000 cancer related deaths occurring every year. About 70% to 80% of the current patient diagnosed in advanced stage accounting without proper medications.More than 7% of deaths in India are due to various types of cancers which contribute to 8% to 10% of global cancer mortality. To lead a step to reduce this rate, this work aims to design a nanobot (nano robot) which can effectively identify the cancer growth using the concept called Positron Emission Tomography that comes under the branch of Acoustic Bio-Signalling.The simulation of the robot will be presented through "robot simulation software" where the tracking is done through embedded programming, so as to configure its movement and requirements through every cycle of "change of state".A prototype of the Nanobot is constructed through hardware with the help of robot-specific apparatus and with the same norms of a line follower robot.

Keywords: Nanobot, cancer, bugbots, radiotracer

1. INTRODUCTION

The robot has to be designed in such a way that it adapts to the environment it is being tested on and responds to the stimuli without any harmful procedures or emissions during the process. A distinctive size of blood borne medical nanobot ranges between 0.5-3 micrometres which is the maximum possible size for the robot to get inside the blood capillaries. The robot which is sent inside detects the cancerous growth with the help of gamma

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detector. The robot then calculates the shortest path to reach the target and travels in that path [1][2]. Nanobot can identifies the moving obstacles, changes its path accordingly and reaches the target in an optimized way. As per the macro specifications required for the nano-design, a prototype of the nanobot will be constructed through hardware with the help of robot-specific apparatus and with the same norms of a line follower robot. The Arduino can track the robot and help it to respond & react to the environment through embedded systems [3][4].

1.1. Motivation

The current Indian population is 1.29 billion out of which the occurrence of cancer is estimated to be around 2.6 million with over 9,00,000 new cancer patient and 6,50,000 cancer related deaths occurring every year. About 70% to 80% of the current patient diagnosed in advanced stage accounting without proper medications. More than 7% of deaths in India are due to various types of cancers which contribute to 8% to 10% of global cancer mortality.

1.2Problem description

The simulation of the nanobot moving inside the blood capillaries by identifying the shortest path will be programmed. The prototype of the nanobot will be developed using embedded systems. The robot is arduino controlled and follows principles of a line follower robot where it travels through a trajectory path and finds its target. This robot shall also sense the obstacles with collision detection functionality. Its movement is tracked using the sensors with deflect the path it is moving.

1.3Related Work

Bugbots are robots stimulated by water-hopping insects with its ability to walk on water which could be used for environmental monitoring, surveillance and search-and-rescue missions[5,6]. It permits precision interactions among the nano scaled objects, which could operate with nano scale resolution. Figure 1 depicts the live nanorobots injected inside the body.

Fig. 1 Live nanorobots inside the body

Nuclear medicine imaging scans utilizes radioactive materials called Radiotracers; a painless medical test which help physicians to diagnose and assess appropriate medical conditions. This tracer is either inserted into the body or inhaled by the patient as a gas. Radioactive emissions from this radiotracer are sensed by a Gamma Camera that produces pictures and provides molecular information.

With the help of this information the practitioners can locate the tumor growth and its percentage which in turn is helpful to identify the treatment type the patient must undergo[7]. The nanobot with the gamma rays detector and a camera installed is sent inside the body. With the help of the Gamma detector the robot identifies its path (Similar to IR robot) and reaches the target (cancer affected cells) area and injects the medicines to the targeted cells. This overall reduces the effect of radiation which is common treatment for cancer as the entire body is exposed to the radiation [8].

2. FEASIBILITY STUDY

2.1. BUGBOTS

Miniaturization of electronics & ICs continue to a point that small model insects are now feasible. The forefront of robotic insect development is military in nature and is being envisioned. The wide acceptance in BEAM (Biology Electronics Aesthetics & Mechanics) using low level responses, robots were able to move over obstacles & explore area around it. High public interest and small rovers cover imaginations [9,10].

2.2. NANOROBOTS

Nanorobots would construct more of it in an artificial environment containing special molecular building blocks. While there are sensory advantages present at the macro scale compared to the limited sensorium available at the nanoscale, proposals for positional controlled nanoscale mechanosynthetic fabrication systems employ dead reckoning of tooltips combined with reliable reaction sequence. This design ensures reliable results, hence a limited sensorial is no handicap, and similar considerations apply to the positional assembly of small nanoparts. This makes possible the rapid elimination of disease and the reliable and relatively painless recovery from physical trauma and it is the convenient correction of genetic defects, and help to ensure a greatly expanded lifespan. The steps involved in injecting nanobot are given in figure 2.

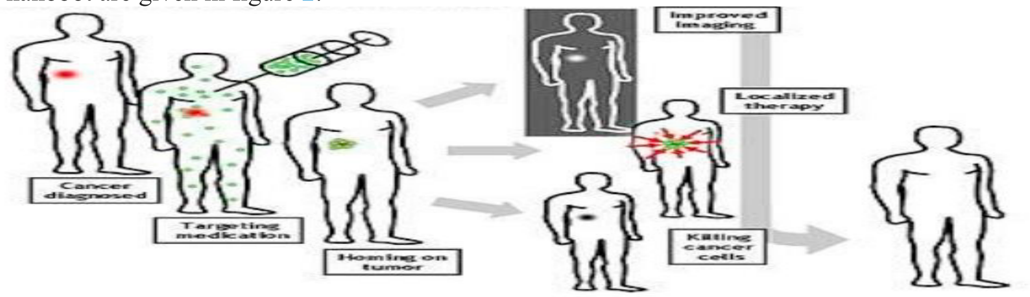

Fig.2 Steps involved in injecting nanobot

2.3. Research and development in Medical Field

In general medical practice, patient is asked to take the radio tracer pill to cure the disease; instead the patient will be treated by expertise to implant tiny nanobot into their bloodstream. These nanobot identify the root cause of the infection, and route itself to the proper system and afford a dose of medication straight to the affected location. This nanomedicine methodology eventually followed to provide treatment for diseases ranging from haemophilia to tumor. Based on capillary passage, the maximum size of a classic blood borne tiny robot varies between 0.5-3 micrometres. These nanobots are made up of with nonzero nuclear magnetic moment 13C carbon atoms with exterior passive diamond coating. Appropriate navigational network with broadcast-type acoustic signalling helps doctor to ensure their location and to interrogate communication track with the device. Through chemo tactic sensors with specific antigens helps these nanobots to identify the type of cell. As soon as nanobot complete its task, it discharges as foreign substances through excretory system of the human begin [11,12].

Nanorobots are designed as same like common bacteria and viruses, such as a tiny bacteria like machine to interact and repel from human systems. These autonomous nanobots primary contains a functional system for transportation, an intelligent processor unit and a nano scale self-charging energy fuel unit. Of these components, design of nano-scale fuel unit is more complicated. The nanobots perform many miracle functions inside the human system [13,14].

3. EXISTING SYSTEM

In the current scenario, the DNA nanobots are gaining importance in the pathological department of medical science.

The main drawbacks of this technology are

i) Injecting a foreign particle inside the so “life strand (DNA)” and making changes creates a lot of risks.

ii) Clusters of nanobots with one another are harmful.
The other existing diagnostic systems include the normal X-Ray Scan, Ultrasound Scanning, MRI Scans etc., that are used to measure the amount of cancerous growth and helpful in identifying the dosage of medications.

3.1 Introduction of problem and its related concepts

The imaging scans use radioactive materials called Radiotracers, which is sent into body and eventually accumulates in the organ or area of the body being examined radioactive emissions. These emissions from the cancerous cells are detected by a special camera (Gamma Camera) that produces pictures and provides molecular information. The nanobot with the gamma rays detector and a camera installed are sent inside the body. With the help of the Gamma rays detector the robot identifies its path and reaches. The cancerous cells have a unique characteristic of absorbing the radioactive materials more which ultimately leads to more the area and inject the medicines to the targeted cells.

3.2 Overview of the proposed system

The robot has to be designed in such a way that it adapts to the environment it is being tested on and responds to the stimuli without any harmful procedures or emissions during the process. A typical blood borne medical nano-robot would be between 0.5-3 micrometers in size, because that is the maximum size possible due to capillary passage requirement.

3.3 Simulating of nanobot

The simulation of the robot will be presented through “robot simulation software” where the tracking is done through embedded programming. The simulation used to visualize the movement of robot inside the blood stream. The simulation is programmed in such a way, once the robot identifies the target; it finds all the possible paths to reach the target. Out of those paths, the most optimum path is chosen for traversal. The robot identifies the obstacles and avoids them carefully, so that there will be no clashes in between.

3.4 Implementing a working robot

As per the macro specifications required for the nano-design, a prototype of the nanobot will be constructed through hardware with the help of robot-specific apparatus and with the same norms of a line follower robot, a robot will be done with an Arduino-controlled system. The Arduino can track the robot and help it to respond & react to the environment through embedded systems. The block diagram of the hardware implementation is shown in figure 3.

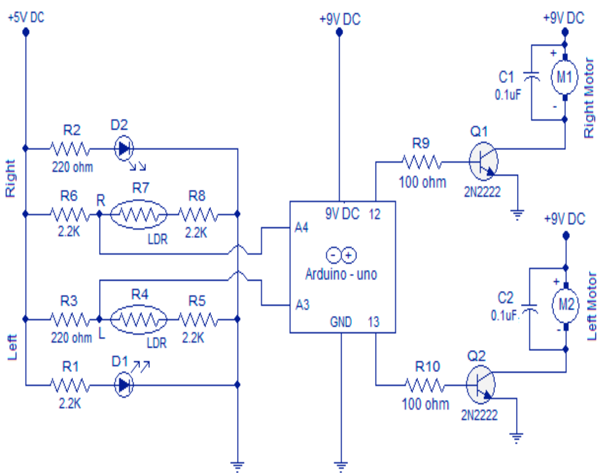

Fig.3 Block diagram of hardware implementation

4. Nanobot

The robot which has been simulated shows how the real nanobot traverse inside the blood capillaries to reach the targeted cancerous cells. The simulated robot is a two-wheeled robot which has proximity sensors at the front panels (Left, Right and Centre). This allows the vehicle to sense both moving and non-moving obstacles that hinder their path. The vehicle is programmed in such a way for every 0.05mm the sensors check for obstacles and move on the shortest path that is selected for traversal. In case of any unexpected obstacles the robot wait for 0.0025 ms and the new path is calculated by avoiding the obstacles. The prototype is developed in such a way the robot follows the shortest path and in case of any hindrance the respective sensors get illuminated indicating the obstacles in the path.

4.1Detailed design

Figure 4 explains schematics description of the robot which has been programmed in simulation. The foremost that has to be done is to design a robot outer schema as per the requirement. For this model a robot is designed with two wheels at rear right and rear left then a small roller in front supports by a rectangular shaft. The sensors are attached to the front panel of the vehicle for detecting the obstacles. The angle for rotation and turning is given in the embedded script. The speed of the vehicle is user-defined as per the design. The environment is been set up by arranging moving and non moving obstacles. Once the simulation is started the robot identifies the shortest path from all the possible paths and traverse to the target.

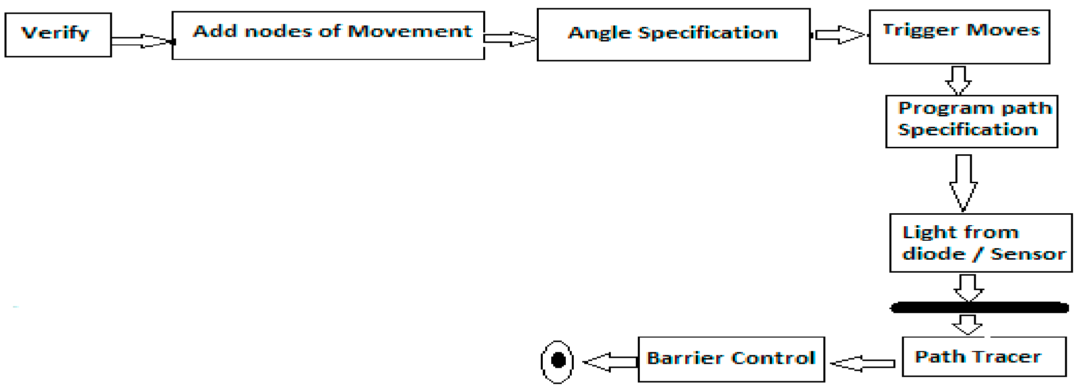

Fig.4 Block diagram of identifying the shortest path

Figure 4 also explains the construction of the arduino controlled robot. First the circuit is designed and the components are assembled as per the circuit design. The arduino controlled robot is programmed and loaded.

5. Module Description

5.1Designing architecture of robot

The robot has to be designed in such a way that it adapts to the environment it is being tested on and responds to the stimuli without any harmful procedures or emissions during the process. Nanotech fabrication is one of the important engineering disciplines that allow designing the robot in the size of 10^{-9}meters. As a draft work, the robot is designed with an isotope of carbon material (diamond) so that it has minimal or no side effects once it is injected inside the body. The nanobot is designed in such a way, that after it injects the medicine in the targeted cancerous cells it comes out of the body through natural metabolism. There will also be no harmful effects on the body when this carbon made nanobots come together.

5.2 Simulating working of robot

The simulation of the nanobot is done using V-REP pro software. The robot is designed and the environment for the robot traversal is set in the scene. Both moving and non-moving obstacles are imported into the scene to study about the robot in adverse and critical conditions. The angle for rotation, the speed of the wheels and the front facing camera are set. With the motion planning module the robot is able to identify all the possible paths and the shortest path is identified for reaching the target. Once an unexpected obstacle comes in the traversal path of the robot, it waits for 0.0025 ms and calculates the new path by avoiding the obstacles. All the programming for simulation is done using embedded programming script.

5.3 Implementing a working robot

As per the macro specifications required for the nano-design a prototype of the nanobot is constructed through hardware that is done with an Arduino-controlled system. The Arduino can track the robot and help it to respond & react to the environment through embedded systems. Arduino 1.0.5- R2 is used as an IDE for programming. In the assembly of components special care has to be taken in checking whether both the motors receive the right amount of current else the total circuit will be short circuited. A special IC (l293d) for dividing the direct current into equal level for both the motors is used. This also assures the safety of the components. The overview of hardware connections is shown in Figure 5.

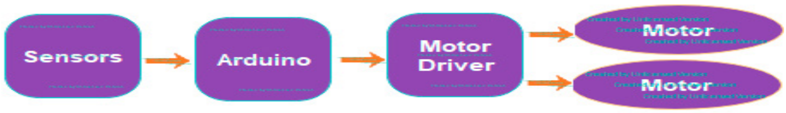

Fig.5 Overview of hardware connections

5.4 Graphic User Interface

5.4.1 V-REP PRO: Figure 6 gives the overview of the movement of nanobot in the V—REP Pro simulation tool.

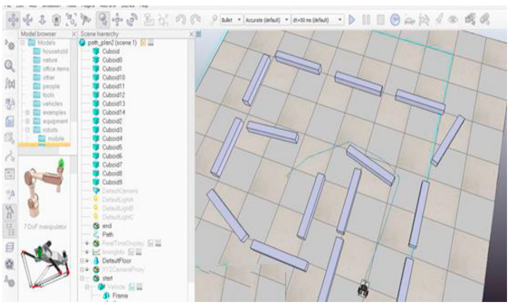

Fig.6 Nanobot in the simulation tool

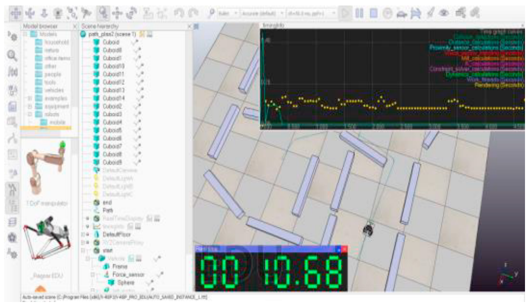

Fig.7 Nanobot simulation with timer & graph

The timer and its graphical representation taken during the movement of nanobot is shown in Figure 7. The appropriate action taken by the nanobot when it encounters a sharp curve in its movement is shown in Figure 8. The activation of IR sensor during its path in v-rep simulation output is given in Figure 9.

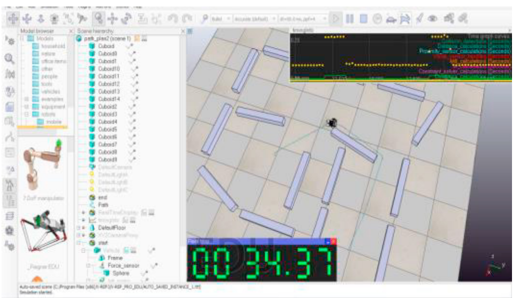

Fig.8 Nanobot taking a sharp curve

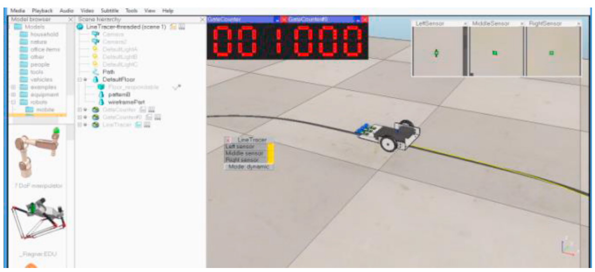

Fig.9 IR sensors get activated and follows the path

5.5 Unit Test Cases

Table 1 gives the complete unit test cases of nanobot with test data and expected versus actual output.

Table 1. The unit test cases

Test Case	Test Data	Expected Output	Actual Output
Identifying cancerous cells inside the body	Nanobot is injected inside the body and the gamma detector is activated	Cancerous cells are identified	Identified
Check for all possible paths	The destination is set	All possible paths are identified	2 to 3 paths are identified
Finding the shortest path	All paths that are found are taken for comparison	The shortest path is identified with the help of algorithm	The most shortest path is identified
Nanobot following the path	The nanobot has to move in the selected path	The nanobot moves in the right path and right direction	The nanobot travels in the correct path
Taking images of the cancerous cells from molecular level	After reaching destination the images have to be taken with the camera carried by the bot	The images are sent as live stream to doctors for consultations	The images are taken and sent
The medicines are injected in the target cells for destroying cancer	The medicines are carried by the nanobot to the cancerous cells	Medicines are injected accurately	Medications are given
Model of the nanobot is designed using arduino	Check whether the Arduino and other components are working properly	The nanobot is ready for Modeling	Modeling is done
The robot designing	All the connections are given with respect to the circuit diagram	The robot is ready for traversing along the selected path	The robot is ready
The robot traversal	The arduino is powered and the program is loaded	The robot moves on the path	The robot moves on the selected shortest path
Backward traversal is stopped	All the sensors are made low	Once all the sensors are turned low the robot eventually stops from moving meaning it reaches the destination	The destination/target is reached and the robot is stopped

6. Performance Analysis

All the possible paths to reach the targeted cells are calculated and out of it, the shortest path is selected. If any obstacle is detected, the nanobot wait for 0.0025 milliseconds as show in Figure 10 and Figure 11. It checks whether the obstacle is moving or fixed and accordingly the new path is calculated for reaching the target. The obstacle detection and line following robot is shown in Figure 12 and Figure 13.

Fig.10 Working of sensors in nanobot

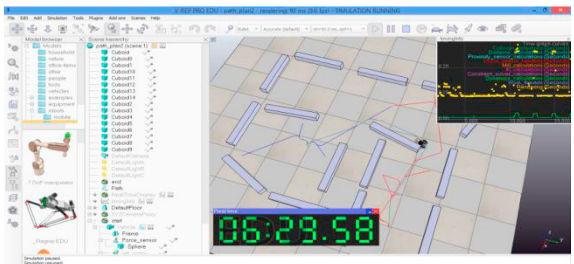

Fig.11 Nanobot waits for 0.0025ms and finds new path

Fig.12 Obstacle detection by the robot

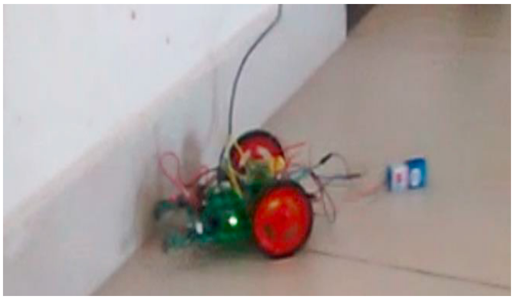

Fig.13 Robot following the line

CONCLUSIONS AND FUTURE ENHANCEMENTS

The prototype which has been designed shall be developed into nanobot with scaling down of functional and cost specifications that paves a way for complete construction of the robot.

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