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Path planning for a car-type mobile robot based on fuzzy logic

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dedication

I dedicate this modest work

To the one who made great efforts for my happiness.

To the one who dreamed of seeing this day.

To the one who guided me and taught me the secrets of life "my father".

To the one who represents my world and my happiness.

To the one who represents the day and the light of my life.

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To my best friends djihen, marwa, nardjess and Amine.

To my brothers whom I love too much.

To my family in general.

To the smallest one in the house Ayoub Nouari .

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List of acronyms

AI : Artificial intelligence

APF :Artificial Potential Fields

GA : Genetic Algorrithm

VBA : Virtual Bee Algorithm

BCO : Bee Colony Optimization

BOD : Dance Bee Optimization

ABC : Artificial Bee Colony

RCGA : Real Coded Genetic Algorithms

UML : Unified modeling language

FL : fuzzy logic

General introduction

Man-made reasoning (AI) is a part of software engineering where machines are prepared and designed to emulate the human conclusive and responsive capacities without human mediation. [1]

Computer-based intelligence is the execution of various procedures pointed toward permitting machines to mimic a type of genuine insight. The need to utilize man-made brainpower is expanding in all spaces.

In 1950; Mathematician Alan Turing fostered a test to gauge man-made reasoning. The Turing test, on account of a progression of inquiries, decides if the appropriate response can be dictated by the machine in this way. If the PC's reactions are vague from those of people, the PC is viewed as falsely shrewd. [2]

The motivation behind man-made consciousness is to plan frameworks fit for repeating the conduct of people in their thinking exercises. Simulated intelligence lays out as its objective the displaying of insight taken as a wonder (just as material science or science which intend to show different marvels).

The logical field that has practical experience in considering, planning and carrying out "keen machines" is called man-made brainpower. It should initially be recalled that "machine" doesn't assign an actual article but instead a programmed framework equipped for preparing data. [3]

Advanced mechanics is a significant sub-space of AI; advanced mechanics can be viewed as a knowledge interconnection of insight, activity, just as the working of robots.

Used to keep up powerful portrayals of their current circumstance, it permits robots to obtain the capacity to convey in normal language.

Mechanical technology is an excellent illustration of a multidisciplinary field that includes numerous subjects like mechanics, mechatronics, gadgets, robotization, software engineering, or man-made consciousness.

Contingent upon the creators' space of beginning, there are thusly different meanings of the term robot, yet they, for the most part, rotate around this one: A robot is a machine furnished with limits of discernment, choice, and activity which permit it to act autonomously in his current circumstance as indicated by his view of it.

With the headway of software engineering and innovation, a more extensive space of examination has opened in the space of advanced mechanics, which is given to machines that perform developments in space. So when we talk about "robot" in man-made reasoning we are alluding to a PC program showing some type of knowledge.

Man-made brainpower and mechanical technology have become progressively intriguing issues in the press and in the scholarly world. In October 2017, Bloomberg distributed an article guaranteeing that man-made consciousness is probably going to be the "most problematic power in innovation in the coming decade" and cautioning that organizations that are delayed to accept the innovation may hazard eradication. Additionally, the next month, the Financial Times announced that the "robot armed force" is changing the worldwide working environment. This premium is likely because of the fast acquire that man-made consciousness has been making in certain applications, for example, picture acknowledgment and conceptual procedure games, and that best in class mechanical technology has been making in labs, despite the fact that boundless business applications might be slacking [4].

The route methodologies permitting a mobile robot to move to arrive at an objective are very different, similar to the characterizations that can be made of them.

In this structure, we call development arranging the issue of the starter computation of the developments important for a robot to achieve a given undertaking.

In its most broad structure, development arranging is characterized in an accompanying way: given a model of the mechanical framework and its current circumstance, arranging a development comprises in ascertaining the development that the framework should make to arrive at a target set deduced. [5]

Robotics is an interdisciplinary field that integrates computer science and engineering.[1] Robotics involves design, construction, operation, and use of robots. The goal of robotics is to design machines that can help and assist humans. Robotics integrates fields of mechanical engineering, electrical engineering, information engineering, mechatronics, electronics, bioengineering, computer engineering, control engineering, software engineering, mathematics, among others.

Robotics develops machines that can substitute for humans and replicate human actions. Robots can be used in many situations and for many purposes, but today many are used in dangerous environments (including inspection of radioactive materials, bomb detection and deactivation), manufacturing processes, or where humans cannot survive (e.g. in space, underwater, in high heat, and clean up and containment of hazardous materials and radiation). Robots can take on any form but some are made to resemble humans in appearance. This is said

to help in the acceptance of a robot in certain replicative behaviors usually performed by people. Such robots attempt to replicate walking, lifting, speech, recognition, or any other human activity. Many of today's robots are inspired by nature, contributing to the field of bio-inspired robotics. [6]

Certain robots require user input to operate while other robots function autonomously. The concept of creating robots that can operate autonomously dates back to classical times, but research into the functionality and potential uses of robots did not grow substantially until the 20th century. Throughout history, it has been frequently assumed by various scholars, inventors, engineers, and technicians that robots will one day be able to mimic human behavior and manage tasks in a human-like fashion. Today, robotics is a rapidly growing field, as technological advances continue; researching, designing, and building new robots serve various practical purposes, whether domestically, commercially, or militarily. Many robots are built to do jobs that are hazardous to people, such as defusing bombs, finding survivors in unstable ruins, and exploring mines and shipwrecks. Robotics is also used in STEM (science, technology, engineering, and mathematics) as a teaching aid [7]

A mobile robot is a robot that is equipped for moving in the encompassing (mobility). Mobile mechanical technology is normally viewed as a subfield of advanced mechanics and data engineering [7].

A spying robot is an illustration of a mobile robot equipped for development in a given environment [8]. Mobile robots have the capacity to move around in their current circumstance and are not fixed to one actual area. Mobile robots can be "self-sufficient" (AMR - self-governing mobile robot) which implies they are fit for exploring an uncontrolled climate without the requirement for physical or electro-mechanical direction gadgets. On the other hand, mobile robots can depend on direction gadgets that permit them to travel a pre-characterized route course in generally controlled space. On the other hand, modern robots are generally pretty much fixed, comprising of a jointed arm (multi-connected controller) and gripper gathering appended to a fixed surface. The joint-arm is constrained by direct actuator or servo engine or stepper engine.

The issue of tracking down the most limited way between two crossing points on a guide might be demonstrated as an uncommon instance of the briefest way issue in diagrams, where the vertices relate to convergences and the edges compare to street portions, each weighted by the length of the section [9].

Over the past 10 years, there has been vast improvement in hardware architecture design for computer information, one of the most important functions being network analysis. The main

problem with network analysis is the shortest path analysis. According to the network being analyzed, the shortest path has a variety of measurements, such as time, to find the path. The problem with determining the shortest path, however, is to find both the fastest and the shortest path. Thus, research in the shortest path always has been a point of interest in graph theory. One of the most important problem that needs to be solved in everyday life since we humans are always searching for the easiest and fastest way to do any of our works [10].

Fuzzy Logic (FL) is a method of reasoning that resembles human reasoning. The approach of FL imitates the way of decision making in humans that involves all intermediate possibilities between digital values YES and NO.

The conventional logic block that a computer can understand takes precise input and produces a definite output as TRUE or FALSE, which is equivalent to human's YES or NO.

The inventor of fuzzy logic, Lotfi Zadeh, observed that unlike computers, the human decision making includes a range of possibilities between YES and NO, the fuzzy logic works on the levels of possibilities of input to achieve the definite output. [11]

In 1965 Zadeh [12] formalized the binary rationale enjoys the benefit of straightforwardness, yet is far eliminated from the human method of thinking. In the event that one takes the case of the capability of the closeness of a snag, the fluffy rationale makes it conceivable to include thoughts, for example, " near enough" or "far", instead of being limited to a twofold definition « obstruction or no obstacle .

This thesis is made up of three (03) sections:

The first section is given to the introduction of mobile robots. An overall outline of the field of autonomous navigation technologies is taken up to inspect the typology of portable robots. We present a best in the class of route all in all and helpful and self-ruling route in powerful conditions with hindrance evasion specifically.

In the second, the commitment to the exploration issue, we present a calculated report on arranging a way for a self-sufficient robot utilizing fluffy rationale. The climate demonstrating with the framework technique is portrayed, and the strategy Fuzzy logic is clarified exclusively. We will talk about the application for the vehicle like mobile robot to achieve a particular errand, all in all, assembly towards an objective and the aversion of hindrances.

In the last part, the entertainment conditions are discussed in short. A couple of investigations are guided with a PYTHON progression environment to evaluate the introduction of our feathery system. [13]

Finally, we wrap up and summarize the entire work, explaining the end obtained through reproduced tests.

Chapter 1: State of the art

1. Introduction

Human conscious method of transportation is quite possibly the most treated tasks in automated examination all through the world. This approach for transportation is normally founded on vehicles like mobile robots. By and by, growing a completely self-ruling vehicle ready to move in unique outside conditions is definitely an important assignment. Perhaps the most significant issues are to foster a productive and precise calculation permitting the mobile robot development in an obscure climate, while regarding non-holonomic requirements.

Objectives are typically communicated in a 2D space through two directions in addition to a direction; this is called an Oriented Goal. Most indoor robots are holonomic and as a rule have decoupled interpretation and turn movement, consequently once the 2D position has been achieved, last direction point can be effectively reached through a solitary revolution. Shockingly, it isn't the situation with non-holonomic robots where revolution is coupled to interpretation. For this situation, situating such robots requires a much incredible and savvy control technique.

A precise last direction is by and large required in outside route for applications, for example, individual's transportation or on self-ruling agribusiness vehicles. Rather than following an exact and complete direction, different methodologies use calculations which depend on fluffy sets to drive the robot from an underlying situation to an objective [14], [15], [16].

Every one of these works has applied their methodologies on non-holonomic versatile robots. Creators in [17] propose a fluffy express way following technique, where a fluffy guideline based framework is created to follow a pre-registered way for a holonomic little size robot proceeding onward complex sharp ways.

Non-holonomic vehicles have an unpredictable and non-direct kinematic and elements, and thusly the cooperation among haggles is incredibly hard to show [18]. Fluffy regulators adapt well to the deficient and dubious information inborn to the subsystem cooperation's and non-linearity. Furthermore, fluffy regulators are uniquely fit to insert the human information on a self-governing versatile robot, without utilizing a total insightful model.

Considering the properties of the fluffy frameworks, a fluffy standard based regulator has been planned and exhibited to perform arranged objective route in an outside common habitat with a business lawnmower robotized [19] The fluffy guidelines embody the master information in a base set, removed from the perception of the manual activity of a specialist driver in a bunch

of field tests. Roused from last referred to works, we propose in this work another technique dependent on FLC, to play out an "Arranged Positioning" on a self-ruling vehicle like robot called Robucar [83].

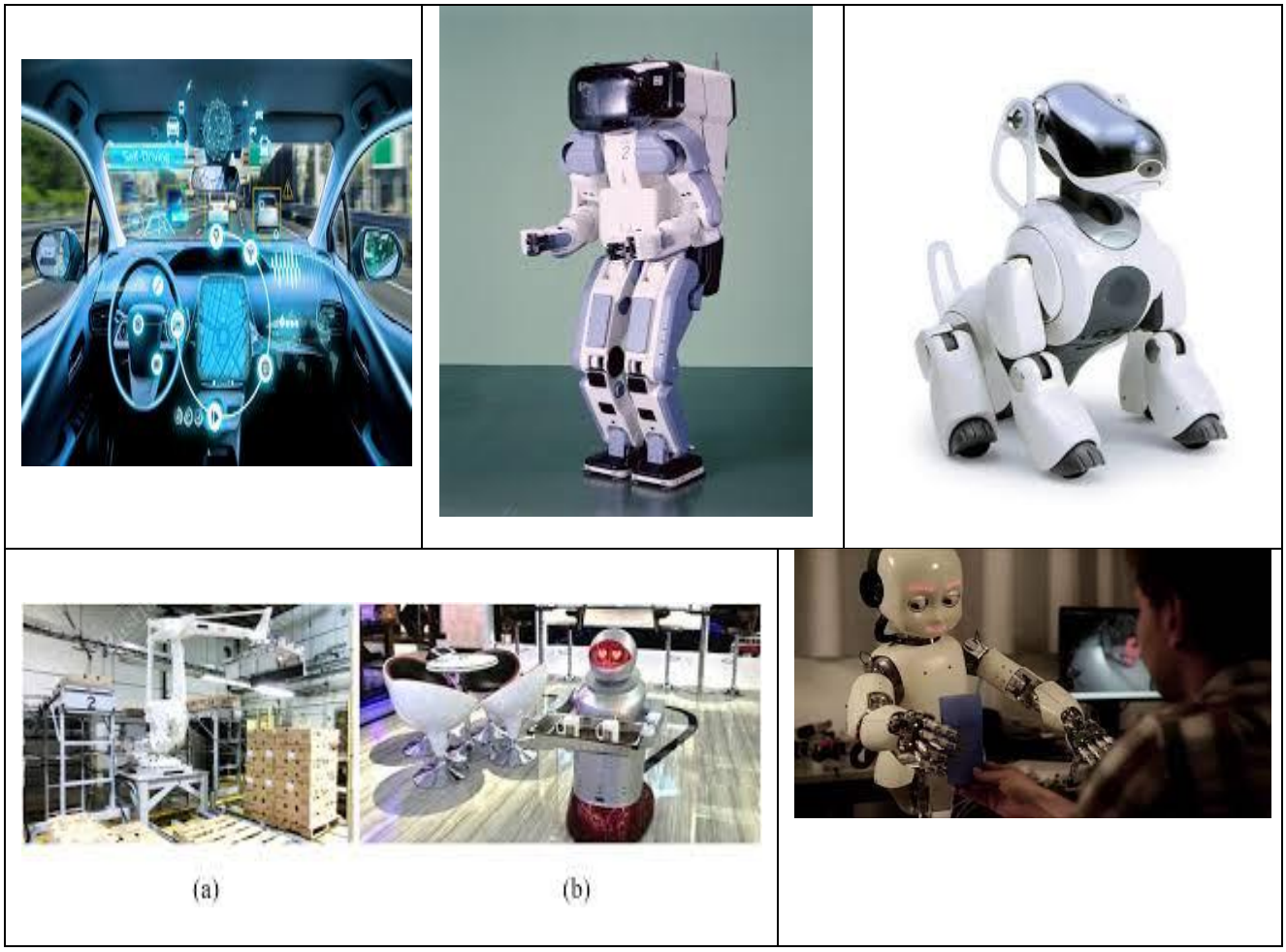


Figure 1. Example of Decent Robots that was made to help humans in several fields [71]

2. Navigation Strategies

The route procedures permitting a versatile robot to move and to arrive at an objective are exorbitantly different, similar to the characterizations that can be made of them.

A. Artificial Potential Fields (APF):

APF is imagined to assemble a field of possibilities on the robot's route climate. The worth of this field is insignificant on the point that the robot should reach and persistently develops as one moves away starting there. The hindrances create a loathsome field of potential for the robot, of significant worth better than some other point not comparing to an impediment of the field potential. Also, the repugnance field reaches out around deterrents with force conversely corresponding to the separation from the snag. The thought is then to request the

robot to move toward the path from the most grounded negative expected angle on the general potential field acquired.

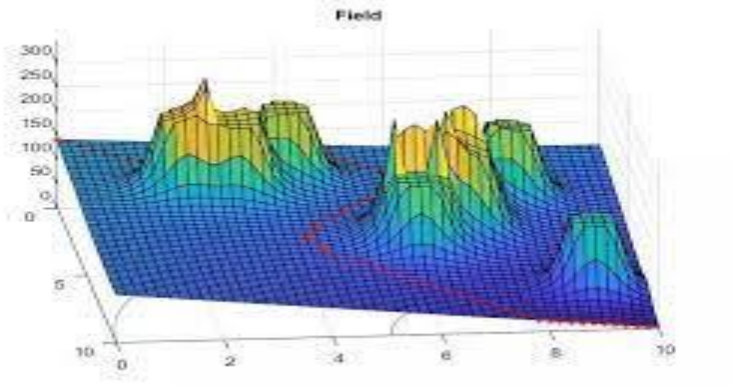


Figure 2. Artificial potential field method [72]

In [20], and in [21], the creators were quick to envision the possibility of fanciful powers following up on the robot. These techniques enjoy the benefit of being easy to carry out, and they were quick to be truly embedded on genuine robots in 1985 by Brooks [22] and in 1989 by Arkin [23]. Notwithstanding the PC hardware actually restricted right now, direction/control computations being quick with this sort of approach, it permits the main trials on generally sluggish robots. In [24], Agirrebeitia proposes an expansion of the guideline of APF strategies for robot routes in a 3D space. The analysis uncovered some common issues identified with the actual guideline of these strategies:

• Local minima creating circumstances where the robot is caught (ordinarily the U-molded snare).

• No entry recognized between obstructions adequately close.

• Oscillations brought about by obstructions and tight paths.

In [25], creators in the numerical field have shown issues of unsteadiness of these techniques (prompting motions), and these issues show up especially emphatically while carrying out these strategies on "quick" frameworks..

B. Artificial Neural network (ANN):

Counterfeit neural organizations are constructed like the human mind, with neuron hubs interconnected like a web. The human cerebrum has many billions of cells called neurons. Every neuron is comprised of a cell body that is answerable for handling data via conveying data towards (inputs) and away (yields) from the mind.

An ANN has hundreds or thousands of fake neurons called preparing units, which are between associated by hubs. These preparing units are comprised of info and yield units. The info units get different structures and designs of data dependent on an inside weighting framework, and the neural organization endeavors to find out about the data introduced to create one yield report. Very much like people need rules and rules to think of an outcome or yield, ANNs likewise utilize a bunch of learning rules got back to spread, a shortened form for in reverse engendering of blunder, to consummate their yield results.

An ANN at first goes through a preparation stage where it figures out how to perceive designs in information, whether outwardly, aurally, or literarily. During this managed stage, the organization contrasts its genuine out-put created and what it was intended to deliver—the ideal yield. The contrast between the two results is changed utilizing back spread. This implies that the organization works in reverse, going from the yield unit to the info units to change the heaviness of its associations between the units until the distinction between the genuine and wanted result delivers the most reduced conceivable blunder.

A neuron is a nonlinear capacity, boundary zed, with limited worth. A neuron contains 2 principal components:

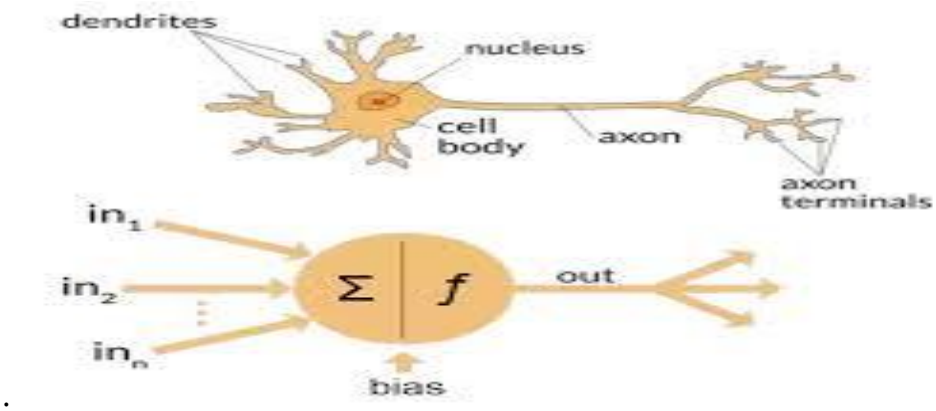
• The loads related to neuron associations.

• An initiation work, the information esteems are increased by their comparing weight and added to acquire an aggregate Ui.

$$Ui= E(x1,\dots .,xj,\dots ..xn) = \Sigma\ Wij\ x\ j \qquad (1)$$

Learning can be perceived as an adjustment of the limit or conduct of a life form achieved by experience. The learning calculation will figure the express standards that permit it to sum up.

The definition of the principles is finished by the difference in the synaptic loads which prompts the difference in the conduct of the organization; the change is completed by a bunch of emphases which makes these organizations ready to respond with new circumstances dependent on the experience passed.



.

$$U_i = E(x_1,\ldots,x_j,\ldots,x_n) = \sum_{j=1}^{n} W_{ij}x_j \qquad (2)$$

Figure 3. Artificial Neural network [73].

C. Ant Colony:

In software engineering and tasks research, the insect state advancement calculation (ACO) is a probabilistic procedure for taking care of computational issues which can be diminished to discovering great ways through diagrams. Fake subterranean insects represent multi-specialist strategies motivated by the conduct of genuine insects [26]. The pheromone-based correspondence of organic insects is frequently the dominating worldview utilized. Blends of fake insects and neighborhood search calculations have become a strategy for decision for various advancement assignments including a type of chart, e.g., vehicle directing and web steering.

For instance, subterranean insect settlement improvement is a class of advancement calculations demonstrated on the activities of an insect province. Counterfeit 'insects' (for example reproduction specialists) find ideal arrangements by traveling through a boundary space addressing every conceivable arrangement. Genuine insects set down pheromones guiding each other to assets while investigating their current circumstance. The recreated 'subterranean insects' likewise record their positions and the nature of their answers; so that in later reenactment emphasizes more insects find better arrangements [27]. One minor departure from this methodology is the honey bees calculation, which is more closely resembling the searching examples of the bumblebee, another social creepy crawly.

This calculation is an individual from the subterranean insect province calculations family, in swarm knowledge techniques, and it establishes some meta-heuristic improvements. At first, proposed by Marco Dorigo in 1992 [28] in his Ph.D. proposition, the principal calculation was meaning to look for an ideal way in a chart, in view of the conduct of insects looking for a way between their province and a wellspring of food. The first thought has since broadened to settle a more extensive class of mathematical issues, and accordingly, a few issues have arisen, drawing on different parts of the conduct of subterranean insects. From a more extensive viewpoint, ACO plays out a model-based search [29] and offers a few likenesses with an assessment of conveyance calculations.

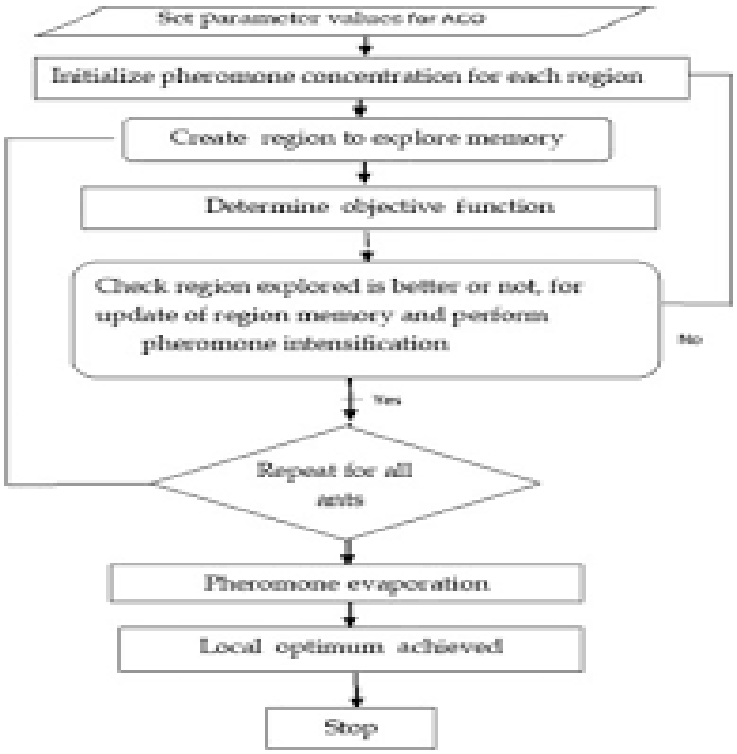


Figure 4. Ant Colony optimization [74]

The robot subterranean insect can remember couples (Perception, Action) and consequently construct a rudimentary portrayal of the room.

The insight may compare to the worth of the incorporation vector and/or the apparent picture, and the activity to the development to be performed (bearing, distance to be voyaged).

These sets are, as it were, the reciprocals of the nearby vectors recently referenced in the bug. To limit the put-away data and in this manner be just about as practical as could really be expected, we characterize the idea of point of decision for where the robot-subterranean insect should settle on a choice.

This is the situation, for instance, for deterrents to stay away from. At that point, the robot-subterranean insect can utilize these couples (perception, activity) by contrasting them with the current circumstance. There is then a progressive change from routine preparation to the programmed utilization of this daily schedule. [30]

The robot-subterranean insect is consequently making an ever-increasing number of developments quick in light of the fact that once the routine is learned and "computerized", it does the economy of the perceptual stage all through this kind of excursion. The robot at that point just uses its sensors at each remembered point of decision to recalibrate itself, and not during each rudimentary development. The directions are increasingly smooth and productive, which relates to the practices we saw in subterranean insects. [31]

Subterranean insect Colony calculations are hearty (they are consistently effective, even if there should arise an occurrence of disappointment of specific people), they are adaptable (a settlement can adjust to another climate) and they are quick acceptable arrangements also the work in equal and the utilization of heuristic data, among others. In any case, there are numerous detriments, we can take a hindering state can occur, runtime some of the time long and doesn't have any significant bearing to a wide range of issues. [32]

D. Bee Colony:

On the off chance that we just utilize a portion of the nature or conduct of honey bees and add some new highlights, we can plan a class of new calculations. In what follows, we address a few calculations (the most popular), without being comprehensive, in light of the conduct of the honey bees during the searching.

The ABC enhancement was proposed by Dervis Karaboga to take care of genuine world and mathematical issue in [33], which is roused by the smart conduct of bumble bee multitudes to getting a hotspot for their food.

ABC calculation models comprise of three gatherings of honey bees: scout honey bees find all food source positions arbitrarily dependent on the moves, utilized honey bee misusing a wellspring of food which come from scouts honey bees, and spectator honey bees to assess food quality [34]. ABC has been broadly utilized in a few applications in various fields like preparing neural organizations, signal handling applications, and AI people group [35]. The overall construction of the ABC calculation is as per the following:

- Stage 1: introduction of arrangements (the number of inhabitants in food sources).

- Stage 2: Employed honey bees search new food sources including more nectar inside the neighborhoods of the food source.
- Stage 3: The passerby honey bees assesses food quality relying upon the data given by the utilized honey bees.
- Stage 4: Start to look for new arrangements haphazardly by scout honey bees.
- Stage 5: Repeat stages 2, 3, and 4 until the best arrangement is accomplished.

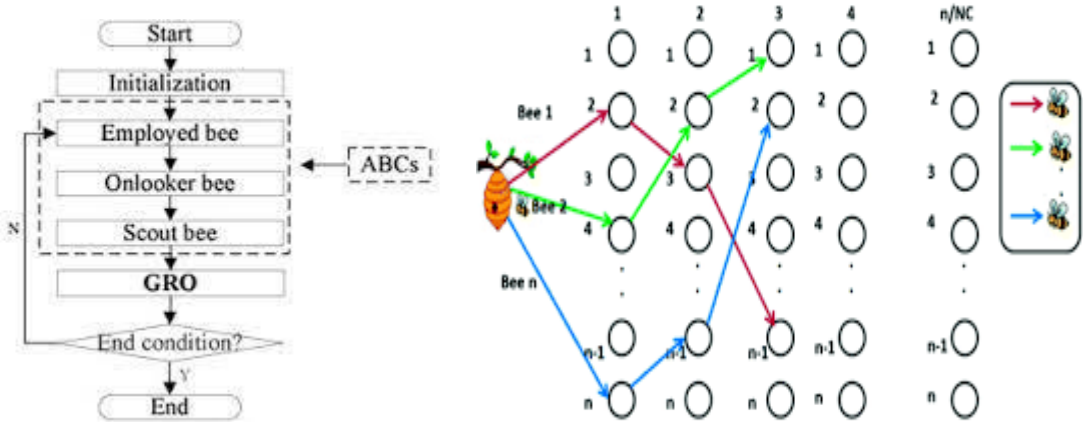


Figure 5. bee colony optimization [75]

E. Virtual Bee Algorithm:

This calculation was created by XinShe Yang in 2005 [36] for tackling mathematical enhancement issues, this can advance capacities and discrete issues, albeit just capacities with two dad parameters have been given as specific illustrations. The game plan of the VBA calculation begins with a virtual honey bee troop, every honey bee moves arbitrarily into the pursuit space, and much of the time, the hunt space can be only a 1-D or 2-space - D. The primary strides of the honey bee calculation virtual capacities for streamlining capacities are:

• Creation of a populace of multi-specialists or virtual honey bees.

• Every honey bee is related with an answer vector with a few boundaries to enhance.

• Coding of improvement capacities (target capacities) and transformation to virtual food (Virtual Food) [37].

• Definition of a rule to convey the course and the distance in a manner like the actual fitness of the honey bees (the dance of the honey bees).

• Update a populace of people in new positions for virtual food research, doing a virtual dance to characterize distance and heading; "the virtual dance of waggle"[38].

After a specific time of development, the most elevated mode, in the number of virtual honey bees or the power/recurrence of the honey bees that make the visit is high, relates to the best assessment.

• Decoding of the outcomes to get the arrangement of the issue.

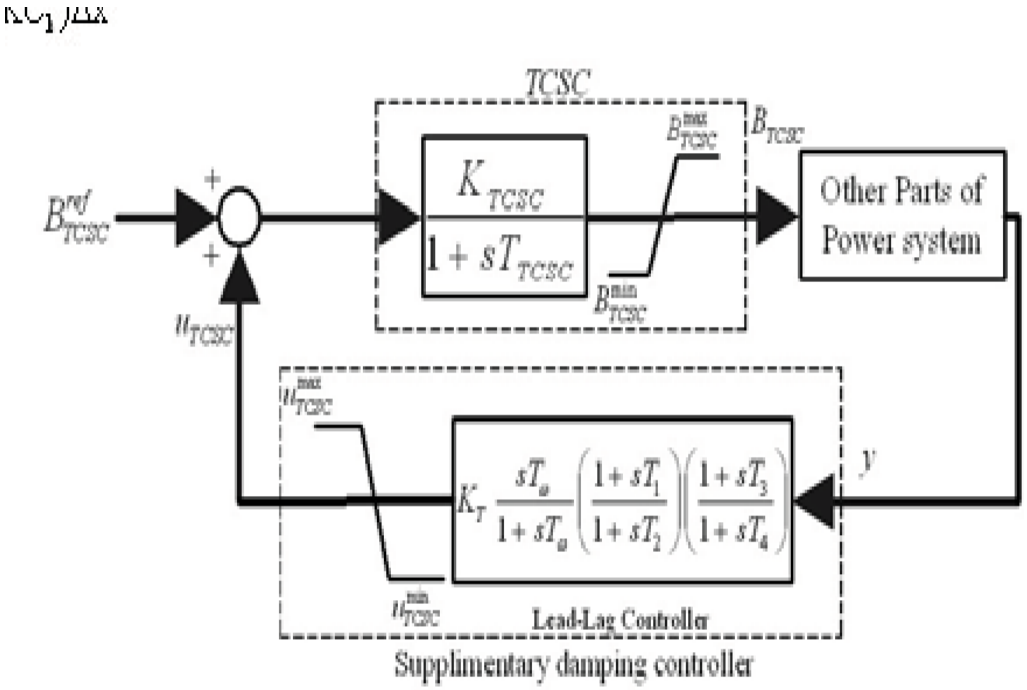


Figure 6. Virtual Bees Algorithm based design of damping controller [76].

F. Bee Colony Optimization

The Bee Colony Optimization (BCO) meta-heuristic has been presented decently as of late by Lučić and Teodorović [39] as another bearing in the field of Swarm Intelligence. The BCO has been effectively applied to different designs and the executive's issues by Teodorović and co-authors [40]. The BCO approach is a "base up" way to deal with displaying where unique sorts of fake specialists are made by similarity with honey bees. Fake honey bees address specialists, which cooperatively tackle complex combinatorial improvement issues.

Every honey bee produces an answer for the issue. To construct one stage in BCO calculation. There are two change stages (venture forward and venture back). In each progression forward, each counterfeit honey bee visits N solutions makes an incomplete arrangement, and afterward gets back to the hive.

The honey bees accumulate in the hive and start the progression in reverse. At the point when every one of the arrangements is finished, the awesome them is resolved, and it is utilized to refresh the best by and large arrangement and like that, an emphasis on BCO is cultivated. Now, every one of the arrangements is eliminated, and another cycle is conceived. Leave 'B' alone the number of honey bees in the hive, and "NC" the number of valuable pushes ahead. At the point when the inquiry begins, all honey bees are in the hive. The pseudo-code of the BCO calculation can be portrayed as follows:

- Initialization: an unfilled arrangement is allocated to every honey bee [41];
- For every honey bee: at. k = 1

    a. Tally the productive pushes ahead)

    b. Assess every conceivable advance;

    c. Pick a stage;

    d. k = k + 1;

On the off chance that k ≤ NC, Go to b. Return of the multitude of honey bees to the hive;

- For every honey bee assess the worth of the goal work.
- Each honey bee chooses haphazardly either to proceed with its own investigation.
- Recruiter, or become the honey bee who does the gather. For every supporter, pick another arrangement from the selection representatives.
- If the arrangements are not finished, go to step (b).
- Evaluate every one of the arrangements and track down the best one among them.
- If the stop model isn't checked, go to step (b), in any case, go to the following stage.
- Show the best arrangement found.

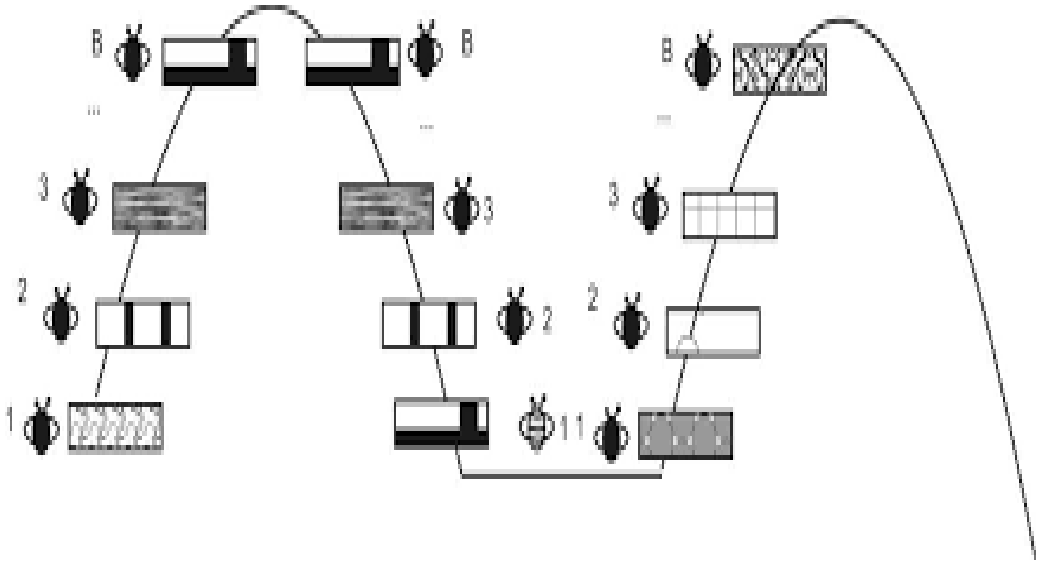


Figure 7. Bee Colony Optimization [77]

G. Dance Bee Optimization

The BOD (Dance Bee Optimization) calculation was created by Laga and Nouioua in 2009 [42] to tackle the issue of T-shading charts. This calculation is propelled by the conduct of honey bees when foraging. The calculation begins by haphazardly situating the n honey bees in the hunt space.

Subsequent to assessing the wellness highlights of these honey bees, the honey bees with the best wellness (first class honey bees) are chosen for neighborhood building. In the following stage, the calculation controls the inquiry nearby the best destinations m found by first class honey bees. Surely, these are the honey bees enlisted to look around the best destinations e, ie. Follow the best artists, are likewise selected honey bees seek after different artists. This enrollment is the vital activity of the BOD calculation. For each enrolled honey bee (arrangement), we partner a neighbor-hood meta-heuristic to look around this arrangement [43].

Eventually, around there, simply the best ones, among m honey bees (arrangements) are subsequently retained to frame the following populace. Note that in nature, there is no comparative limitation; this limitation is acquainted in the calculation with diminishing the number of answers for investigation.

To finish the honey bee populace, the leftover honey bees are haphazardly produced. At the end of every cycle, the settlement will comprise from one perspective, of m honey bees illustrative of every area (to escalate the hunt) and then again, of honey bees allocated arbitrarily (to expand the pursuit).

These means are rehashed until a predefined halting rule (various emphases or a stagnation number). The dance is upward the dust is toward the sun. The dance is vertical and is coordinated downwards the dust is the other way to that of the sun.

The point that the plane of the dance makes with the vertical is equivalent to the point that the food makes with the Sun in an even plane. The bearing of the sun is in this way addressed by the vertical, seen from beneath upwards; and the point of the heading of the crown jewels with that of the sun is recreated comparable to the azimuth.

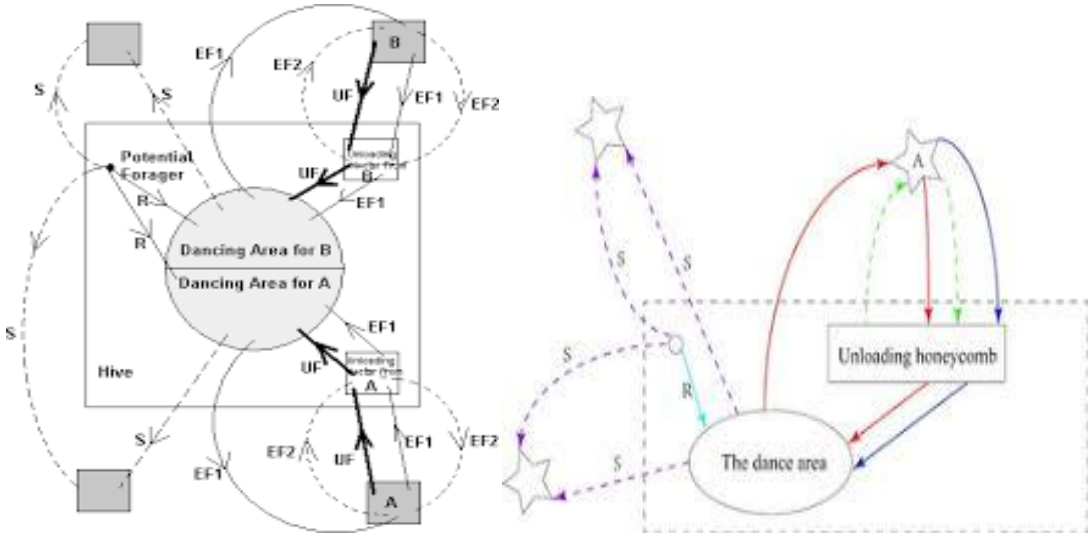


Figure 8. Dance Bee Optimization [78]

H. Artificial Bee Colony

The ABC (Artificial Bee Colony) calculation was created by Karaboga and Basturk in 2007 [31], examining the conduct of genuine honey bees to discover the food source, called nectar, and offer data from food sources to others honey bees in the home. In this calculation, fake honey bees are characterized and classified into three gatherings: honey bees (honey bees that quest for food), onlookers (honey bees of perception), and scouts are answerable for discovering new food varieties, (the new nectar source). For every food source, there is just one utilizing honey bee. That is, the quantity of working drones approaches the number of food sources.

Among the upsides of the honey bee province technique, notice may:

- Very successful in discovering ideal arrangements.
- Defeats the issue of the nearby ideal.
- Easy to execute.
- The utilization of a few movable boundaries.
- Sensitive to incredibly troublesome issues.

Yet, there are numerous weaknesses, as most advancement calculations highlight, an instrument of development and a system of enhancement, increases a counter for arrangements that don't improve to arrive at an edge limit, fixing this boundary is an issue in itself, and little qualities can kill an answer before to investigate its neighborhood deficient, while enormous qualities may trap the calculation in minima premises for a few cycles.

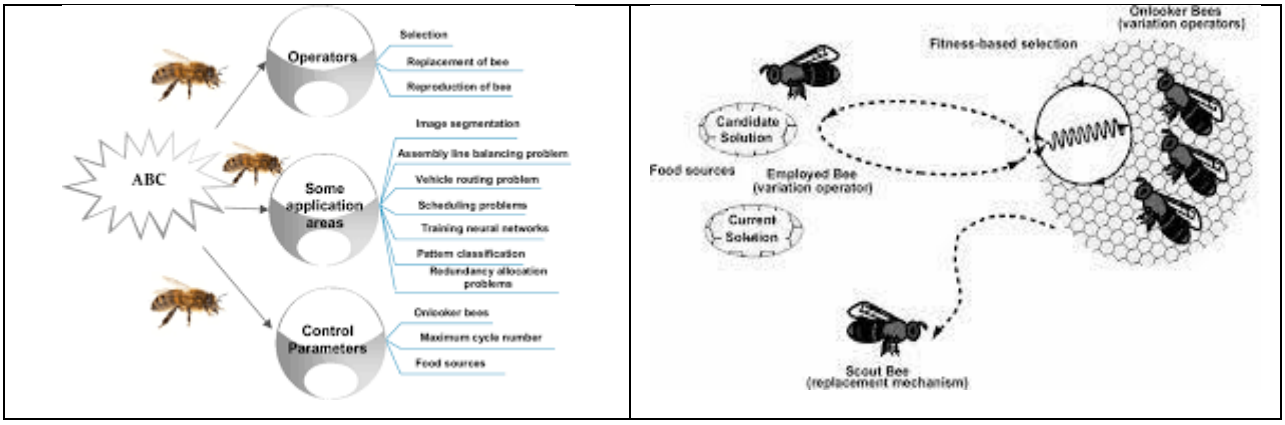


Figure 9. Artificial Bee Colony **[79]**

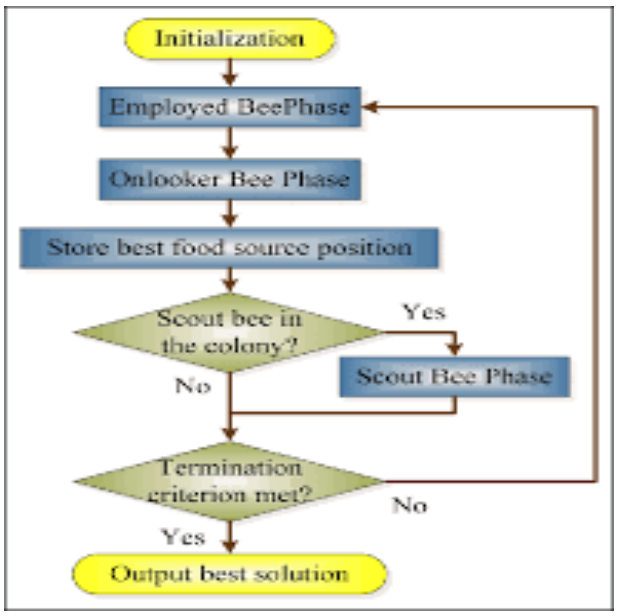


Figure 10. Flowchart of Artificial Bee Colony **[80]**

I. Genetic Algorithm

Genetic Algorithms have a place with a family calculation called Evolutionary Algorithms [44]. These calculations are stochastic streamlining strategies enlivened by Darwin's hypothesis of development, whose objective is to get a surmised arrangement, at the right time. Hereditary Algorithms use strategies got from hereditary qualities and common development: crosses, changes, determinations, and so forth ..., they address a stochastic improvement techniques for request "0", which implies neither congruity nor differentiability is fundamental for the smooth running of the strategy, just the information on the worth where the nearness of the capacity to be enhanced is adequate. Thus, the viability of a hereditary calculation relies upon the great information on the issue to be dealt with.

Hereditary calculations are the aftereffect of examination by John Holland and his partners and understudies at the University of Michigan who, as right on time as 1960 [45], dealt

with this subject. The curiosity brought by considering the hybrid administrator notwithstanding the changes is this administrator which permits to draw nearer to the ideal of a capacity by consolidating the qualities contained in the various individuals of the populace.

Hereditary calculations depend on the thought of characteristic choice and apply it to a populace of solutions to a given issue.

The phases of execution of a hereditary calculation:

- Initial population: We should pick an arbitrary populace of n chromosomes, every chromosome here presents an impending area of the robot, and we can likewise transform it so every quality addresses the next bearing of the robot.
- Wellness work: Measure the wellness of every chromosome in the populace.
- Choice: Create another populace with reiteration following stages until the populace is finished.
- Hybrid and change: Each pair creates two kids, in these activity two chromosomes trading at least one section for information of the new chromosomes. On the off chance that there is no blending, the outcome is a precise of the guardians.
- Change implies that quality in a chromosome can fill in for another in an arbitrary way.

Stop test: If this rule isn't checked then go to step (2).

J. Fuzzy Logic

In 1965 Zadeh formalized the Binary rationale enjoys the benefit of effortlessness, however is far taken out from the human method of thinking. On the off chance that one takes the case of the capability of the vicinity of a snag, the fluffy rationale makes it conceivable to include thoughts, for example, "close to enough" or "exceptionally far", rather than being restricted to a twofold definition « impediment or no obstruction ».

The standard of a regulator dependent on fluffy rationale comes in 3 stages:

A fuzzification step, which will change the information factors into fluffy factors;

A stage utilizing a table of rules of conduct, coherent guidelines of the kind "in the event that (condition 1) and/or (condition 2) (activity on the yields)";

A last, the defuzzification step deciphers the activity controlled by the guidelines of conduct in order to ship off the actuators. [46]

The fuzzification stage utilizes fluffy stretches, which will delimit the space of the info factors in a specific number of fluffy subsets (for instance for closeness, we can have exceptionally close (contact), very close, normal distance, far enough, and extremely far); enrollment capacities are then used to characterize the level of truth (likelihood of having a place) of the fluffy variable as an element of the information amount.

These capacities can be a triangle, Gaussian, and so on Hence for given distance estimation, the part transport rule will advise us "there is a 95% possibility that the hindrance is sufficiently close, 5% possibility of being in touch".

This thought depends on the way that there are consistently vulnerabilities about the sensor estimations and the data accessible when all is said in done.

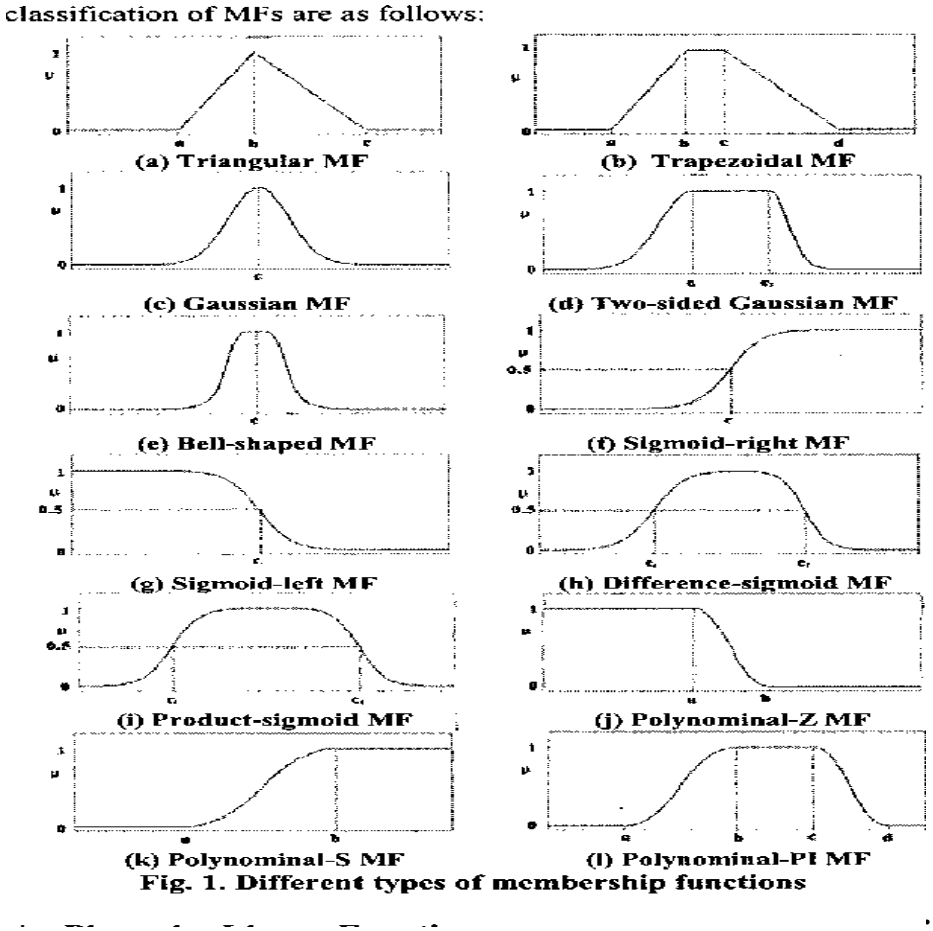


Figure 11. Membership functions [81]

The subsequent advance is the improvement of rules of conduct for the robot, following the blend of fluffy information factors. The guidelines of conduct table are constructed physically and are subject to the experience of the individual who will change the regulator. For a portable robot, a standard can be: "if there is a genuinely close obstruction on the right, you need to turn left and reduction the speed of the robot". The last advance is to change the conduct got by the principles table, in charge of the robot.

One technique that can be utilized to do this is that of the focuses of gravity, which will comprise of making the weighted normal of the orders to be applied. The weighting being identified with the probabilities of participation of each info variable. A fluffy regulator to permit

the route of a-vehicle mobile robot with double controlling has been concentrated in [47]. This regulator permits the robot to arrive at its last position while regarding the kinematic requirements of the robot, yet for the second doesn't consider snags.

In [48], the creators utilize the right/left evenness of the rationale rules of conduct of the robot to rearrange these, and accordingly, decrease the computation time.

The issue of these fluffy rationale techniques is for the most part equivalent to that of the APF strategies, the issue of neighborhood minima which brings about the robot having the option to stay caught in impasses for instance.

A procedure for escaping these snares has been proposed by Xu in [49]. This procedure utilizes virtual focuses to remove the robot from the snare into which it has fallen when it perceives that it has fallen into a snare.

Another difficulty that emerges from the fluffy rationale strategies is that they are excessively particular for a given kind of climate, and in this manner, they experience the ill effects of issues of transformation to various environments. Notwithstanding, there are supposed learning strategies that permit the robot to alter its principles of conduct as it investigates another climate.

3. Comparison between Methods

Method	Advantages	Disadvantages
Fuzzy logic	- Translate human experience into a bunch of rules. - The nearest to human explanationing. - It isn't substantial as far as calculation, saving time, and memory space.	- The route way isn't ideal in light of the approximate thinking technique. - Requires the accessibility of a specialist - Robot activity is restricted by these guidelines.
Neural Networks	- Build an answer in a straightforward manner - The capacity to ascertain a definite route way	- The information portrayal strategy.

Ant colony	- Very high flexibility. - Perfect for diagram based problems.	- It has a component of evolution and enhancement - Big qualities may trap the algorithm for numerous cycles and it can kill an answer before the abuse.
Bees Colony	- Effective in tracking down the best arrangements and simple to implement - Get freed of the nearby ideal issue - Sensitive to complex favorable to blems.	- It has a component of evolution and expansion - Big qualities may trap the algorithm for various cycles and it can wipe out an answer before the abuse.
Genetic algorithm	- AGs utilize the encoding of dad parameters - AGs are dealing with a population of focuses - The utilization of probabilistic transition rules to keep away from neighborhood ideal - Synthesis of streamlined shapes, structures, and composite materials.	- The issue of planning modern organizations - Recognition of structures and learning by decreasing it - Pattern location on bioinformatics - Synthesis of electronic circuits.

4 Conclusion

In this part, we have introduced a cutting edge on route for versatile robots and the different calculations accessible to us to oversee it, for the disclosure of the briefest ways and distances in a climate. We have additionally seen the various stages; we likewise introduced the benefits and limitations of every technique and tracked down that no route approach that denies an answer that wipes out all issues has been experienced. Accordingly, we see that route is an exceptionally dynamic field of exploration and that new strategies show up routinely. This audit of the writing uncovers the significance of utilizing heuristic strategies to figure the movement calculation issue as a streamlining issue in light of a legitimate concern for fulfilling a few requirements simultaneously.

In the next chapter we will discuss the design of our proposition to solve the problem of planning a path for an autonomous mobile robot using fuzzy logic.

Chapter 2: Design

1. Introduction

Robot, any consequently worked machine that replaces human exertion; however, it may not take after people apparently or perform capacities in a humanlike way. Likewise, mechanical technology is the designing order managing the plan, development, and activity of robots. the robot regulator, is explicit and consequently not versatile to another robot. Be that as it may, there is both modern and exploration interest to characterize a conventional model of a robot regulator.

As far as examination, the improvement of uses requiring sharing of the robot's current circumstance with its current circumstance prompts search for solid and versatile structures far eliminated from the fixed designs of exemplary robots whose quick climate is shut to the human administrator.

In this unique situation, AI (fluffy rationale) techniques for the detail and plan of ongoing frameworks should help in this displaying of the intricate framework that is a robot regulator. The way following requires specialized information to know the family member or total situation of the vehicle.

In this work, we propose the control dependent on fluffy rationale and which is planned to manage the vehicle along direction. The vehicle should consistently know its situation in space by a general situating framework (the camera). In reality, to determine the fluffy control law we should know the separation from the vehicle to once of edges of roads and the edges if it is right or left.[52]

2. Study of Project

2.1. Our Problem:

Our concern is to discover a way for a self-ruling vehicle like a mobile robot. Where the point is to discover a way to arrive at the ideal end state insecure manner. To discover ideal answers for enormous scope arranging issues, we explore how fluffy rationale can be adjusted and applied to these streamlining issues with unmanageably huge and profoundly complex inquiry spaces. All the more explicitly, our work targets responding to the accompanying exploration question:

How a car-like mobile robot can move from a beginning stage to a completion point in a safe manner?

2.2. The proposed solution:

To react to the investigation question, the assessment bases on changing beforehand existing and developing new powerful cushy systems to deal with tremendous extension progression issues of endeavors applied to a mobile robot.

The purpose of the fuzzy system is to determine the speed of the right and left wheels according to the distance from the obstacles around the robot. [54]

2.2.1. Problem definition

We revolve around the going with condition: In the basic, state there is a starting characteristic of a way where obstacle or traffic lights are put heedlessly.

A robot should arrive at an appearance point from a beginning point, the robot has a beginning position (Xs, Ys) and an arrival position (Xa, Ya), the robot doesn't have a clue about the climate.

We were keen on tackling the accompanying issues: arranging a way for this robot to get from the beginning point to arrival point securely.

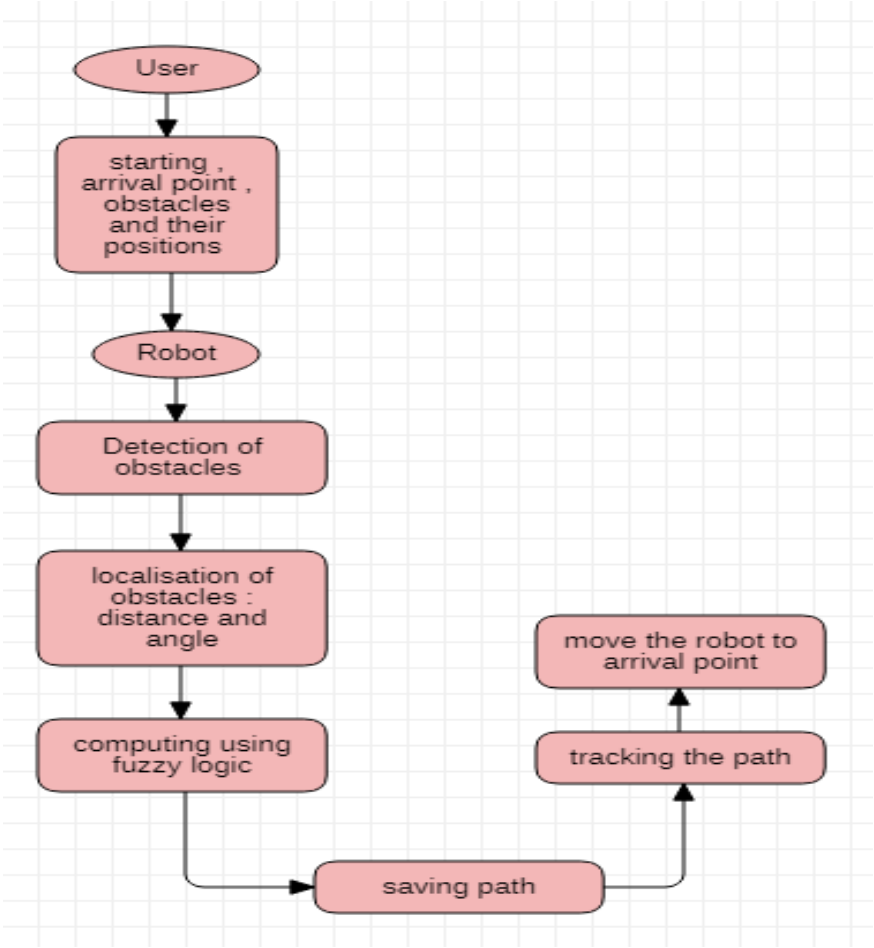


Figure 12. General Architecture of our system

2.2.2. Use case diagram:

A use case is a strong unit addressing usefulness apparent from an external perspective. It gives a start to finish administration, with inception, an unfurling, and an end, for the entertainer who starts it. Subsequently, a utilization case models assistance given by the framework, without forcing the exemplification of this help.

The robot has four principal activities: search, move, the evasion, and location of impediments:

•Research is a cycle of distinguishing objectives.

•The development is exercises changes of positions on the directions got from the regulator.

•Obstacle evasion is likewise a cycle of moving toward objectives.

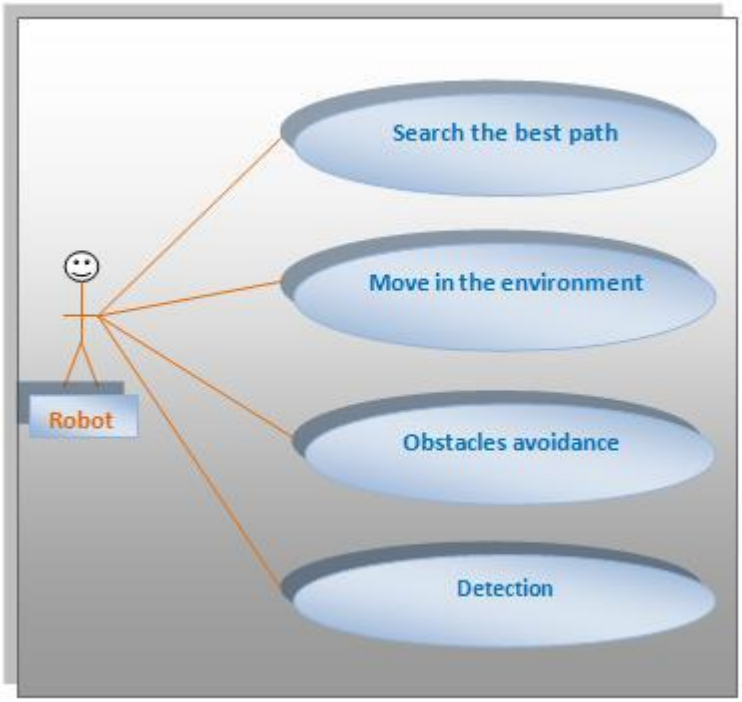


Figure 13. use case diagram

In our graph, we have a solitary element that represents our robot as the primary entertainer. This one has 4 focal operations to perform that being:

•The track of the way: our robot is arranged at the beginning situation in a climate with a completion highlight reach, it is then dependent upon it to choose the best speed to apply.

•Move in the climate; with the completion point in record the robot starts to make its development along with the climate

•Obstacles aversion: hindrances are arbitrarily positioned in the climate as per the beginning and finishing point entered, consequently it is fundamental for the robot to keep away from them when they cross its way.

2.2.3. Sequence diagram:

A succession graph is a Unified Modeling Language (UML) outline that addresses the arrangement of messages between objects during an association. An arrangement outline comprises a gathering of items, addressed by lifesavers, and the messages that these articles trade during the cooperation.

Succession charts address the grouping of messages sent between objects. They can likewise address the control structures between objects.

Correspondence between these items is demonstrated by the grouping outlines in Figure 2.3.

The robot gets the directions from the direction computation class by the send arrangements strategy then it sends them at each update of position with the choice technique. (at a picked testing recurrence of the new arrangements).

The cooperation's depicted in these two charts make it conceivable to derive a worked-on class outline.

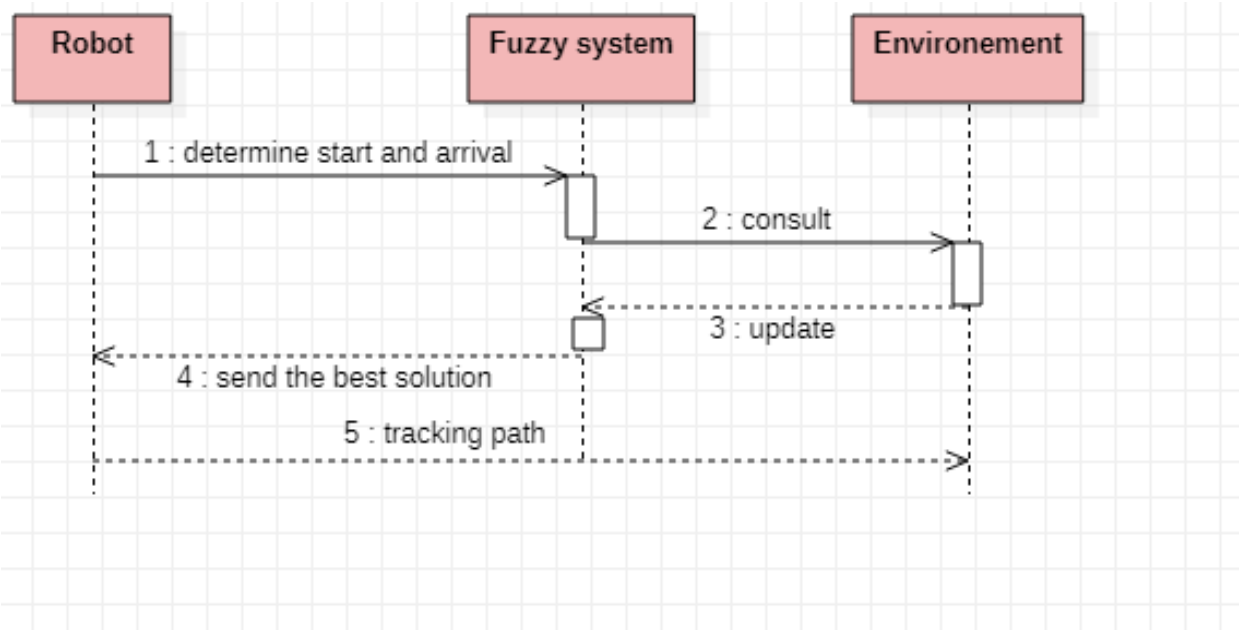


Figure 14. Sequence diagram illustrating the robot action

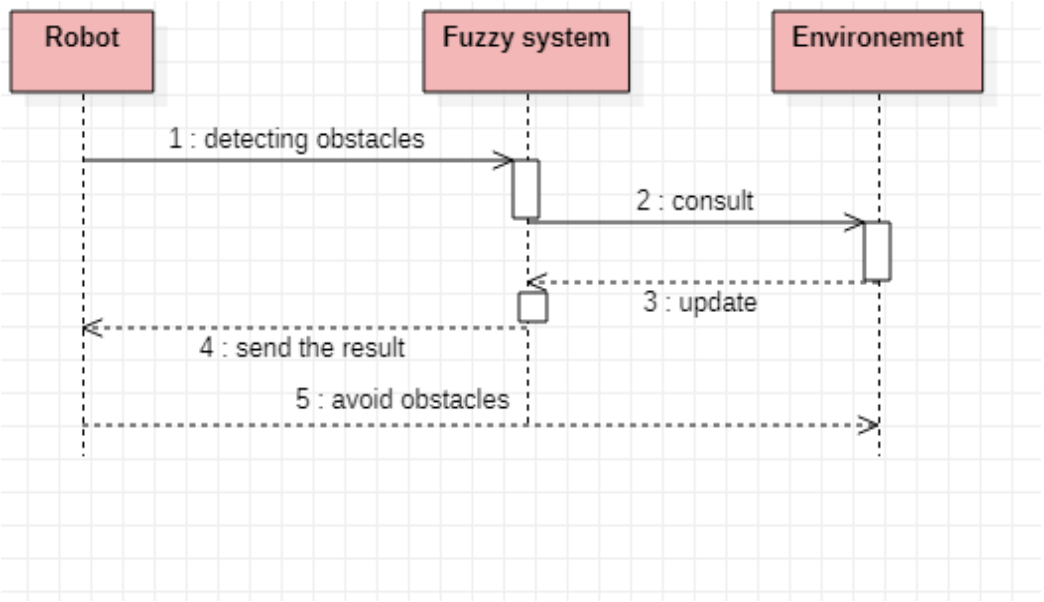


Figure 15. Sequence diagram illustrating the robot action

Our interaction starts when the robots get the direction computation class, which then sends over to the fluffy rationale framework for investigation. The framework initially talks with the climate close by if there are any impediments ahead in the way. On the off chance that there are any deterrents, it ascertains the distance and the speed required on the two wheels as indicated by it. After this, it settles on the choice to turn or stops or keep getting across the way

2.2.4. The Activity Diagram:

In UML, an action graph (or activity diagram) gives a perspective on the conduct of a framework by depicting the succession of activities of an interaction.

Movement outlines are like data preparing flowcharts since they show the streams between activities in an action. Movement graphs can, be that as it may, likewise show synchronous equal streams and substitution streams.

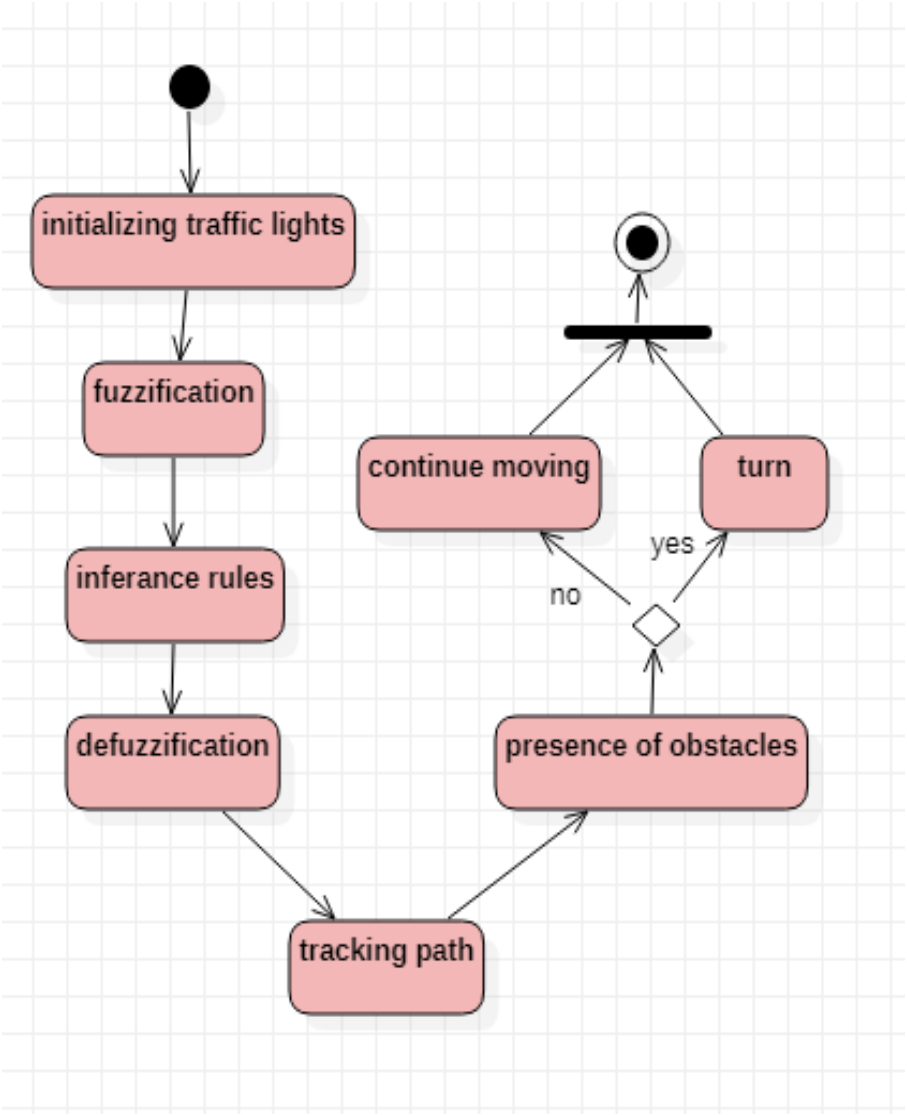


Figure 16. Activity Diagram

Start from the introduction of traffic signals (or hindrances), the client starts with the meaning of etymological factors, in beginning, where it characterizes the enrollment work utilized for fuzzification.

2.2.5. The Class Diagram:

The class chart represents the static design of the data model, particularly the current articles and their inward construction and their associations with different things. A class chart ought not to present any data of a fleeting sort.

Content: classes, subclasses, traits and qualities, techniques, joins (variety, speculation, structure), classifications, and reliance.

The robot class should deal with the arrangement of direction ages and orders so the robot doesn't stop between two directions.

It has particular conduct contrasted with different classes.UML expresses this behavior by the use of Statecharts which allow representing the parallelism well.

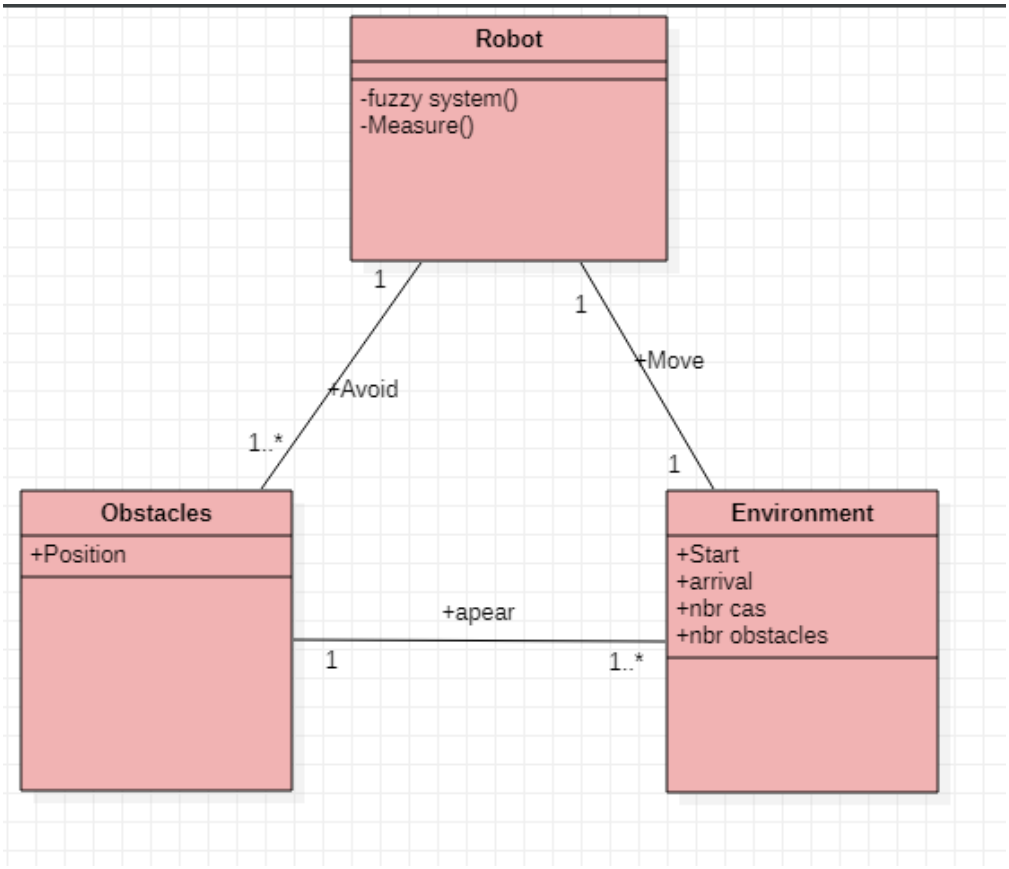


Figure 17. Class Diagram

•Robot class deals with all the fluffy rationale activity, which is essentially dealing with the fuzzification, rules of deductions, and defuzzification.

•Environment Class It deals with the passage of the beginning and finishing focuses, and the estimations of the way picked.

•Obstacles Class it deals with all activities of the hindrances including positions.

2.3. FL Architecture:

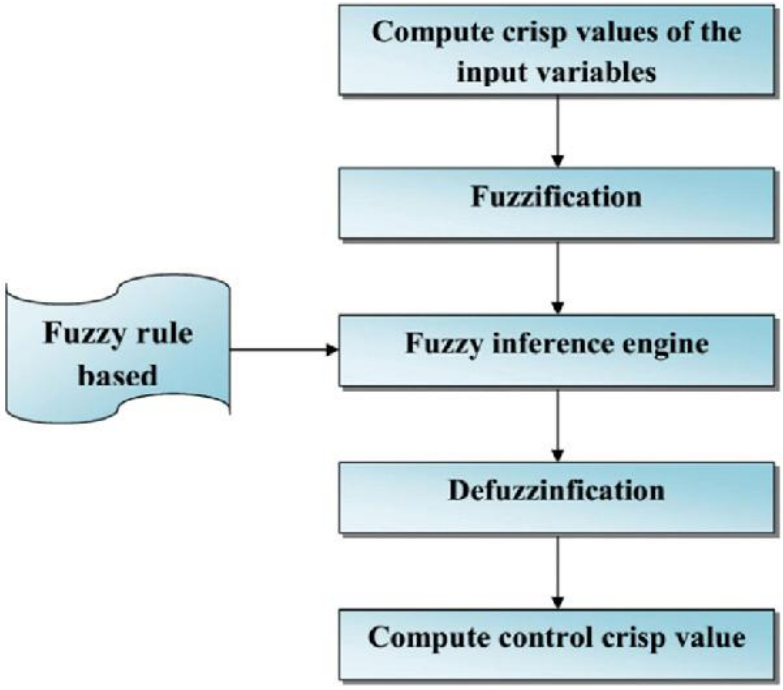


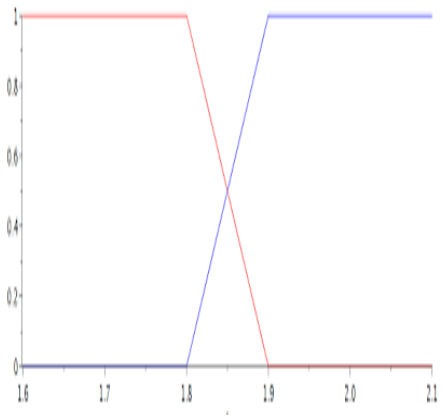
Figure 18. General Flowchart of a fuzzy logic system.

The plan of a fluffy rationale framework begins with a bunch of enrollment capacities for each info and a set for each yield. A bunch of rules is then applied to the enrollment capacities to yield "fresh" yield esteem. The initial step is along these lines to decide the semantic info and yield factors.

2.3.1 Linguistic variables

As info, we have the distances of the robot to the impediments in front, on the left, and on the right. In our framework, I consequently picked two semantic factors to request to address distance information: the variable small_distance and large_distance. At the yield, we need the rates of the wheels of the robot. For the model, a wheel speed is addressed by a PWM signal obligation cycle. This proportion is somewhere in the range of 0 and 1. The etymological factors picked to qualify this obligation cycle are small_speed, medium_speed, and the variable high_speed.

Since we have our information and yield semantic factors, we need to pick participation capacities. A distance is supposed to be little in the event that it is short of one meter and enormous in the event that it is more noteworthy than three meters. The obligation cycle is little on the off chance that it is zero, medium on the off chance that it is 0.5, and huge in the event that it is 1. The enrollment capacities are consequently exceptionally straightforward.



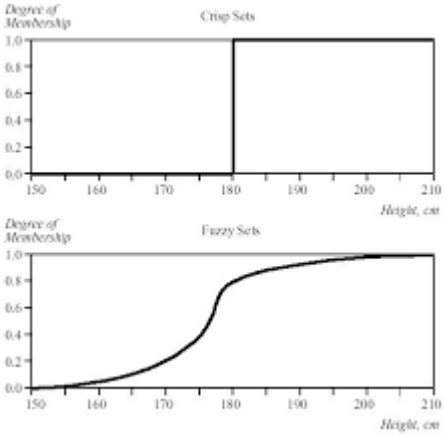


Figure 19. membership function for distance **Figure 20.** membership function for speed

Here, the enrollment capacities for the obligation cycle are specific since a semantic variable address just solitary obligation cycle esteem.

Note: obviously, I just picked two phonetic factors for every info information and three for each yield information for model.

2.3.2 The rules of inference

For our situation, having three sensors with two phonetic factors for each sensor information, we will have all things considered $2^3 = 8$ principles of deduction which compare to the accompanying 8 cases:

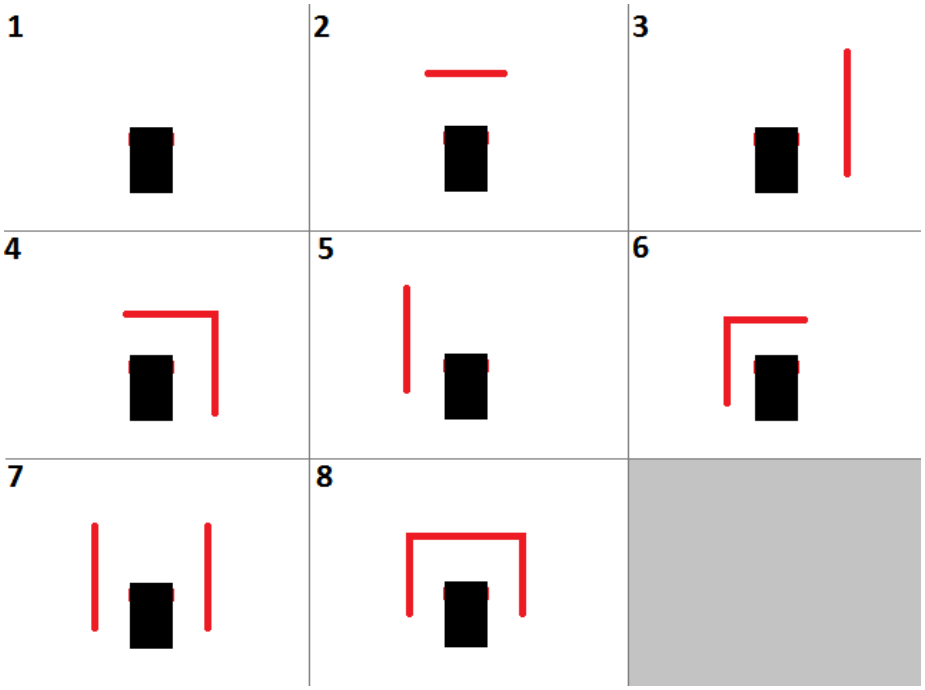


Figure 21. Cases of rules of inference

Case one:

The primary case is the situation where no-snag is recognized. For this situation, we need to go directly at max throttle.

Case two:

Here, on the off chance that you have an impediment in front, however nothing on the sides, you need to turn. At irregular, we will decide to turn right. So fast is required on the left haggle on the correct wheel.

Case three:

In the event that a hindrance is available just on the right, we go marginally to one side. The speed of the correct wheel will be high while that of the left wheel will be medium.

Case four:

In the event that we have distinguished an obstruction to one side and ahead, we go strongly to one side. The speed of the correct wheel will be enormous and that of the left wheel will be little.

Case five:

In the event that you recognize a divider on the left, you should go somewhat to one side. The speed of the left wheel will be high while that of the correct wheel will be medium.

Case six:

On the off chance that there is a divider to one side and in front, we will go strongly to one side. The speed of the left wheel will be enormous and the speed of the correct wheel will be little.

Case Seven:

In the event that the way is clear in front, however, there are two deterrents on each side of the robot, at that point, we move mindfully. The speed of the two wheels will be normal.

Case eight:

At last, assuming the robot recognizes close-by deterrents on every one of the sensors, it should pivot. Arbitrarily right. The left wheel will turn at high velocity while the correct wheel will turn at low speed.

The surmising rules will in this manner be:

• IF left_distance = enormous AND forward_distance = huge AND right_distance = huge THEN left_speed = huge AND right_speed = huge

• IF left_distance = huge AND forward_distance = little AND right_distance = huge THEN left_speed = huge AND right_speed = little

• IF left_distance = enormous AND forward_distance = huge AND right_distance = little THEN left_speed = medium AND right_speed = huge

• IF left_distance = huge AND forward_distance = little AND right_distance = little THEN left_speed = little AND right_speed = huge

• IF left_distance = little AND forward_distance = enormous AND right_distance = huge THEN left_speed = high AND right_speed = medium

• IF left_distance = little AND forward_distance = little AND right_distance = enormous THEN left_speed = huge AND right_speed = little

• IF left_distance = little AND forward_distance = huge AND right_distance = little THEN left_speed = medium AND right_speed = medium

• IF left_distance = little AND forward_distance = little AND right_distance = little THEN left_speed = high AND right_speed = little.

2.3.3 Defuzzification

Prior to defuzzifying, it is important to have just a single etymological variable of each kind (specifically six phonetic factors altogether, three for every wheel). For that, we choose to make the disjunction of the guidelines:

• rule_1 OR rule_2 OR rule_3 OR rule_4 OR rule_5 OR rule_6 OR rule_7 OR rule_8

When we have our six semantic factors, it does the trick to apply a barycenter estimation on every one of the etymological factors to decide the obligation patterns of the privilege and left wheels.

$$\begin{cases} \text{Left\_speed} = \dfrac{\text{left\_speed\_high}*1+\text{left\_speed\_medium}*0.5+\text{left\_speed\_low}*0}{\text{Left\_speed\_high}+\text{left\_speed\_medium}+\text{left\_speed\_low}} \\ \text{right\_speed} = \dfrac{\text{right\_speed\_high}*1+\text{right\_speed\_medium}*0.5+\text{right\_speed\_low}*0}{\text{right\_speed\_high}+\text{right\_speed\_medium}+\text{right\_speed\_low}} \end{cases}$$

2.3.4 The choice of operators:

Since we have every one of the means of our fluffy framework, we simply need to pick the administrators that we need to utilize. Here, we won't muddle our lives, we will pick:

- The insignificance administrator for the AND inside the guidelines
- The maximality administrator for the OR between rules

3. Conclusion

In this section, we portray our fluffy framework for exploring a versatile, independent robot. A power standard was created. This rule comprises of discovering an answer for great execution which is touchy to vulnerabilities. The goal is to proceed onward the way from the starting point to the arrival point securely.

We have introduced the various graphs: outline of instances of commencement, arrangement charts, action chart, and class outline. These charts made our work more clear the issue; to get an answer to the issue of development of the portable robot in spaces with snags.

The reenactment results introduced give promising answers for the independent control of the portable robot, particularly in less muddled conditions. In all cases, the robot can accomplish its goal by staying away from obstructions.

We've proposed a fluffy rationale to tackle this issue on the grounds that the construction of fluffy rationale frameworks is reasonable and clear. The fluffy rationale is likewise broadly utilized today on a business and research center scale. Moreover, better and more effective control of machines and cost reserve funds can be made conceivable by fluffy rationale.

In the following section, we will introduce the instruments and dialects utilized in our application and some captures of the execution of our algorithm with discussing our results according results of others algorithm developed earlier.

Chapter 3: Realization

1. Introduction

To show the self-governing control of the portable robot, we utilized an application created under PYTHON [55] which is a smart framework with a few capacities used to reenact the conduct of the robot in obstruction aversion to arrive at the objective and to survey the exhibition of the strategies utilized.

Streamlining issues are turning out to be more mind-boggling and the fast advancement of innovation has utilized a developmental methodology progressively fundamental.

Also, the expense/execution proportions in equal IT [56] frameworks keeps on diminishing. The developmental methodology is utilized in the plan and execution of meta-heuristics to speed up research, and to improve the nature of the arrangements acquired, to improve strength and tackle issues for a huge scope.

In this theory, our examination is done on the issue of preparation a way for a vehicle like a self-governing mobile robot.

We have proposed another transformative methodology for taking care of the issue of preparation a way for a vehicle like a self-ruling versatile robot, in light of fuzzy logic.

2. Tools and working environments

2.1. Software environment:

Python is the most generally utilized open source programming language for IT experts. This language has impelled itself to the highest point of foundation the board, information investigation or programming improvement. In reality, among its characteristics, Python outstandingly permits engineers to zero in on what they do instead of in transit they do it [57].

Python offers a few valuable highlights for amateurs and specialists the same.

From the outset, it is not difficult to learn and use. Its highlights are not many, which permits you to make programs rapidly and with little exertion. What's more, its grammar is intended to be clear and direct. Another benefit of Python is its prevalence.

This language chips away at all major working frameworks and PC stages. Furthermore, regardless of whether it is plainly not the quickest language, it makes up for its gradualness with its adaptability.

At last, regardless of whether it is mostly utilized for prearranging and robotization, this language is likewise used to make proficient quality programming. Regardless of whether it's applications or web administrations, Python is utilized by countless engineers to make programming. [84]

Figure 22. Python Program [82]

2.2 StarUml

StarUML is an open source programming displaying instrument that upholds the UML (Unified Modeling Language) structure for framework and programming demonstrating. It depends on UML rendition 1.4, gives eleven distinct sorts of outline and it acknowledges UML 2.0 documentation. It effectively upholds the MDA (Model Driven Architecture) approach by supporting the UML profile idea and permitting to create code for numerous dialects.

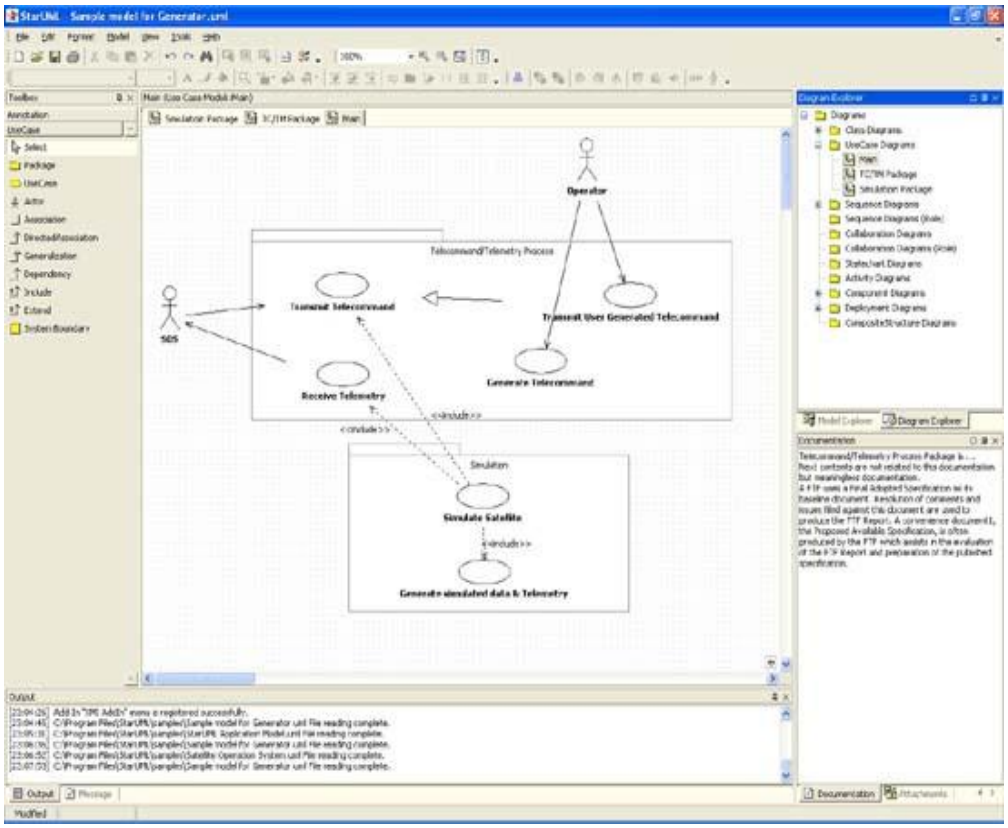


Figure 23. StarUML - Open Source UML Tool [58]

3. Description of the different modules

3.1. The environment:

The routing space needs, in some structure, a PC.

The map is a sort of a simulation of a road with traffic lights placed in some places in it with the car-like mobile robot simulation ruling on the road from a starting point to the end of the path with respecting those traffic lights .[59]

3.2. The operating system needed

3.2.1 Process To Install UBUNTU :

We go to the Ubuntu download page by clicking here and select the arrangement of 64 pieces and afterward click on "Start Download". Then, at that point, It will start to download an ISO picture with Ubuntu Linux to our group.

- Once downloaded the ISO record, we have two choices: copy it and introduce it from a CD/DVD or do it in a pendrive of at any rate 2 GB, for what we will require programming that runs from Windows and is called Universal USB Installer.
- Execute the Universal USB Installer application and select in sync 1 the Ubuntu dissemination 12.04 Desktop, in sync 2 We pick the area of the ISO record that we have downloaded and in sync 3 Select the letter of the USB drive (IMPORTANT: WILL ERASE ALL DATA!!) and snap on "Create":

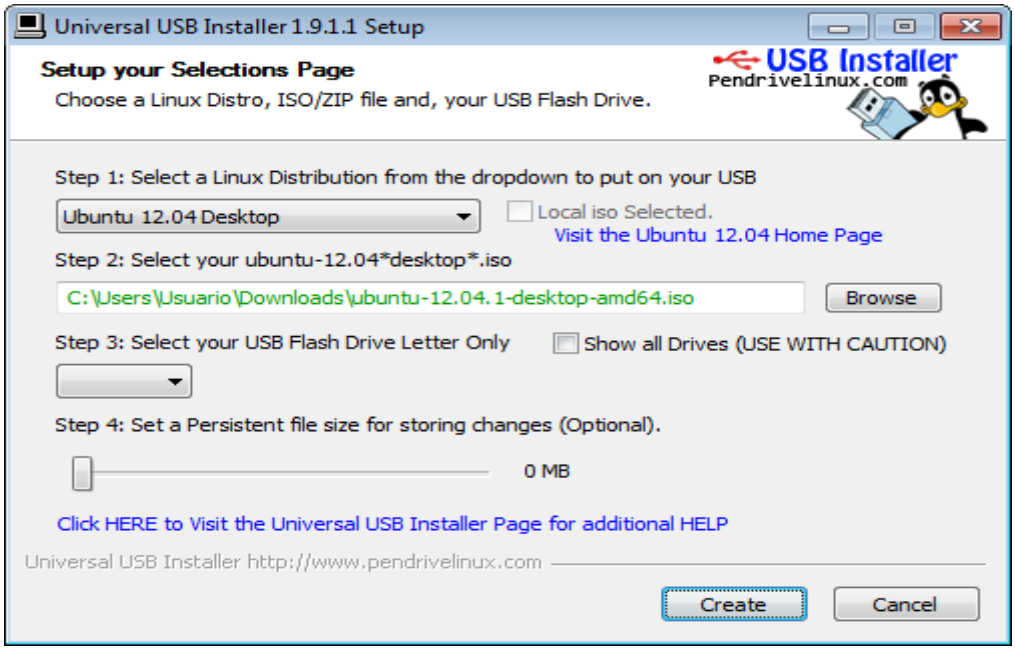


Figure 24. capture of choosing the Linux distribution

- When the cycle is finished, we remove the USB drive securely and turn off the PC.

- Connect the USB drive to the PC advance and it turns on.
- As soon as the Acer logo seems we press F12 and when the boot menu seems to pick the USB drive.
- The Linux establishment starts naturally.
- Then, we Select the Spanish language or any other language and snap on "install".

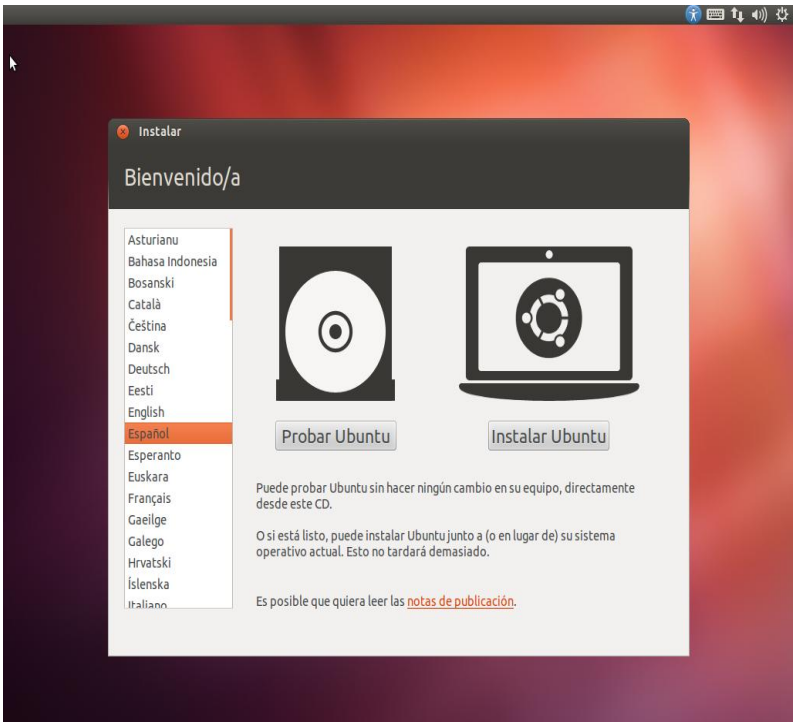


Figure 25. Capture that shows the start of the installation

During the establishment, it is conceivable that we will have the alternative of having the PC associated with the Internet so that lower bundles most refreshed. In the event that we have this chance, Ubuntu will identify it consequently and we will have the choice of going ahead "Download refreshes while ywe introduce". Additionally, we can introduce outsider programming (for instance, to play MP3 sound records) yet this alternative is our decision, depending on our way of thinking, we Choose a choice or another. In the wake of picking the choices that most interest us, we Click on "Continue".

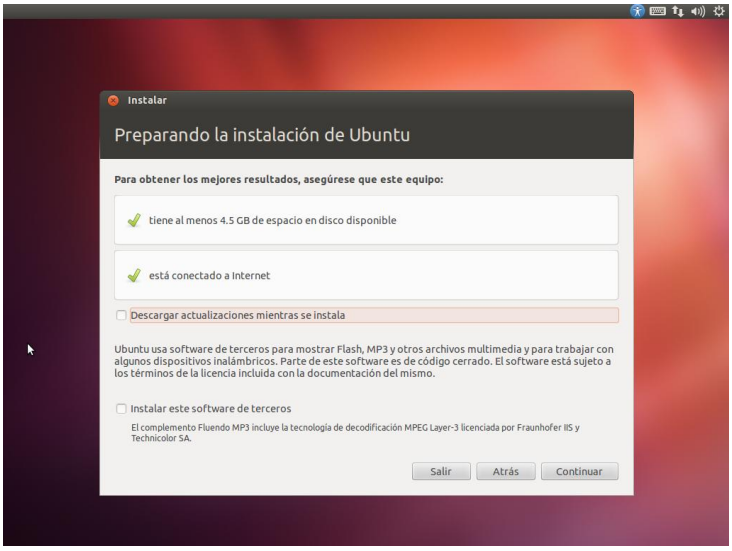


Figure 26. the preparation of the installation of Ubuntu

As we apparently introduced Windows prior to introducing Linux, We ought to have an unpartitioned space, by what we will pick the alternative of "Introduce Ubuntu close by Microsoft Windows". When chosen the ideal alternative, we click on "Continue"

Figure 27. choosing where to install Ubuntu on your disk

Then, will introduce the Linux circulation, and keeping in mind that introduced will request that we present and information as our name, PC name, secret word, and so on… We will fill as it is asking us to.

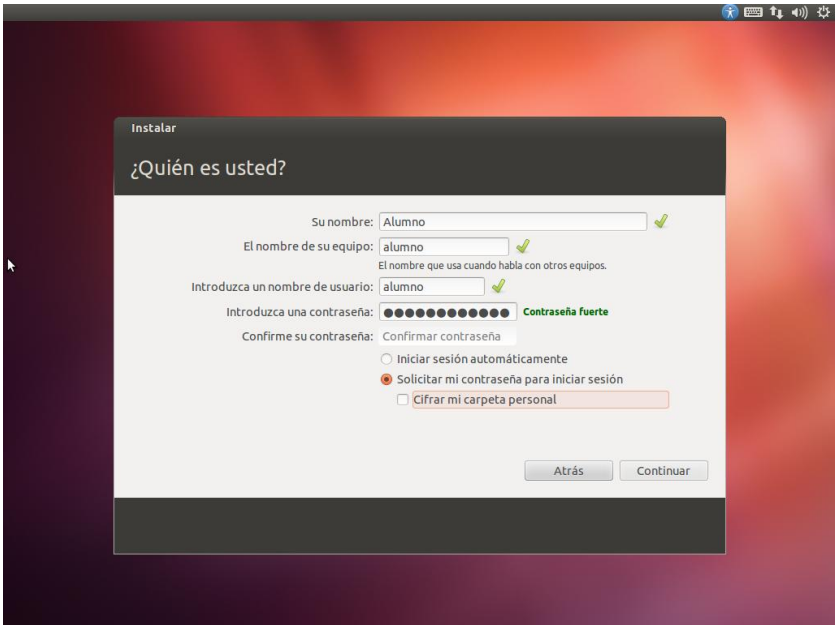


Figure 28. filling data while installation begin

Once every one of these means as of now has introduced Ubuntu introduced with Windows and the following boot, prior to beginning any working framework, will get us a menu to choose the working framework that we need to begin the PC.[60]

3.3. Robot move:

The robot (the simulation of the autonomous car) moves in the path according to 8 rules of inference that corresponds to 8 cases.

3.4. The path

The path is a simulation of a trajectory in a normal road with smart traffic lights in it that are placed on the road to control the movement of the car according to the 8 rules that we saw earlier which is made using pictures of maps, how traffic lights control the movement of the car when the traffic light is red and near the car, start to slow down, its speed till it gets right in front of the light if it still red it stop if it turns to green it increase its speed again and continue moving.

4. Implementation

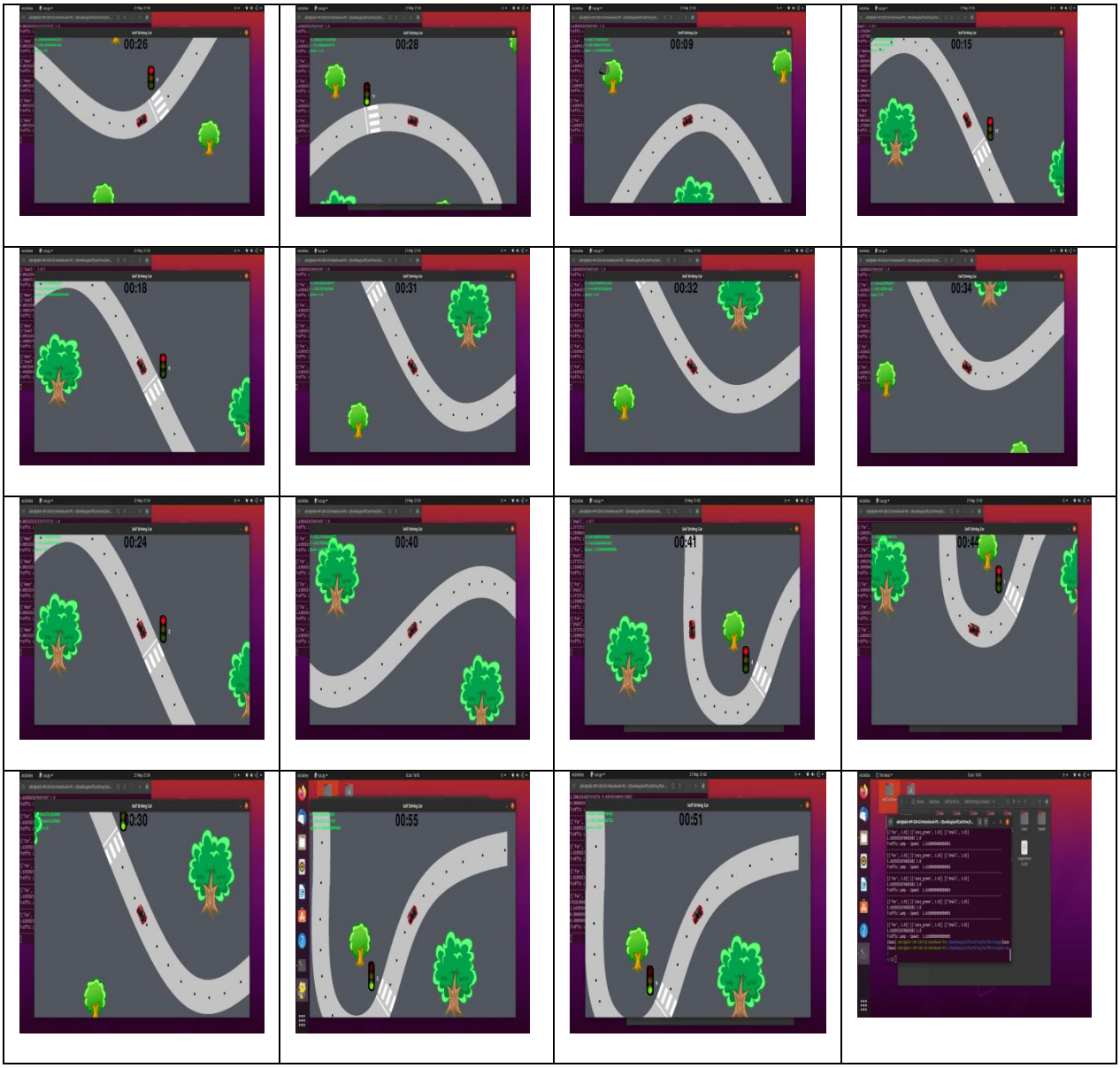


Figure 29. Some captures of the application during execution

- In the first picture the car stops because the red light is on and wait until the green light.
- In the second picture the car moves again when the green light is on and track the path.
- As u can see in the third one the border of the road are considered as obstacles and the care moves across the path with avoiding its borders.
- In the fourth picture the car stops again because the red light is on again.
- The same idea for the fifth , ninth , eleventh and twelfth pictures .
- For the sixth, seventh, eighth, tenth pictures the car is moving and avoiding obstacles across the road.
- And for the thirteenth, fourteenth and fifteenth pictures the car continues its movement when the green light is on.

- And for the last one its shows us the back round of the terminal during the execution of our system.

finally our car moves from a starting point which is the beginning of the path to an arrival point by avoiding obstacles like road borders for examples and respecting traffic lights instruction to get to the end of the path safely.

4.1 How the fuzzy logic system works

Fuzzy logic works on the idea of choosing the yield dependent on suspicions. It works dependent on sets. Each set addresses some etymological factors characterizing the conceivable condition of the yield. Every conceivable condition of the information and the levels of progress of the state are a piece of the set, contingent on which the yield is anticipated. It chips away at the guideline of If-else-the, for example In the event that An AND B, Z.

Assume we need to control a framework where the yield can be anyplace in the set X, with a conventional worth x, to such an extent that x has a place with X. Consider a specific set A which is a subset of X with the end goal that all individuals from A have a place with the span 0 and 1. The set An is known as a fluffy set and the worth of A(x) at x means the level of participation of x in that set. The yield is chosen dependent on the level of participation of x in the set. This allocating of enrollment relies upon the presumption of the yields relying upon the sources of info and the pace of progress of the data sources.

These fluffy sets are addressed graphically utilizing participation capacities and the yield is chosen dependent on the level of enrollment in each piece of the capacity. The enrollment of the sets is chosen by the IF-Else rationale.

By and large, the factors of the set are the condition of the information sources and the levels of changes of the info and the enrollment of the field , upon the rationale of AND activity of the condition of the information and the pace of progress of the info. For a multi-input framework, the factors can likewise be the various information sources and the yield can be the conceivable consequence of the AND activity between the factors.

5. Conclusion

In this section, we have attempted to introduce in a basic manner the various stages through which we went. Another developmental methodology has been appeared to plan a path for a self-governing versatile robot.

This methodology can manage the robot to move self-sufficiently. The proposed approach improves the presentation of routes on some levels, particularly concerning fuzzy

logic. This method can be used in different fields like automotive systems, for applications like 4-Wheel steering, automatic gearboxes. Applications in the field of Domestic applications incorporate Microwave Ovens, Air Conditioners, Washing Machines, Televisions, Refrigerators, Vacuum Cleaners. Different applications incorporate Hi-Fi Systems, Photo-Copiers, Humidifiers and so forth “

We used fuzzy logic because A Fuzzy Logic System is flexible and allows modification in the rules. Indeed, even loose, mutilated, and mistake input data is likewise acknowledged by the framework . The systems can be easily constructed. Since these systems involve human reasoning and decision-making, they are useful in providing solutions to complex solutions in different types of applications.

Conclusion and Perspectives

The issue of self-sufficient route of a portable robot in indigenous habitats has stimulated developing interest lately, Roboticists try to continuously build the level of self-rule of their robots, until arriving at complete self-sufficiency and reasonable for extremely long missions. The completely self-governing development of a versatile robot in unique conditions is a difficult that is as yet hard to tackle. It requires the execution of functionalities empowering the insight/choice/activity cycle to be completed. To have the option to adapt to the wide assortment of circumstances that the robot can during route. In an overall manner, by this examination we featured the interest of the shrewd framework not just for the self-governing control of portable robot, we utilized the PYTHON. The apparatuses given by the python permit demonstrating of wonders that can in some sense approach human thinking. Audit of various works showed that Fuzzy Logic control is perhaps the best methods in the plan and coordination of practices for versatile robots route. [69]

The Fuzzy control addressed a helpful instrument to plan different practices by the utilization of phonetic standards. It likewise gave a powerful procedure to blend and intervention of practices. Then, at that point, two fluffy regulators intended to show impact and vigor of the fluffy control in a route framework. The acquired outcomes demonstrated the fruitful activity and adequacy of the fluffy control in producing smooth movement, decreasing route time and expanding the robot security. Generally speaking, benefits of fluffy control in the plan of a route framework are: I) Capability of taking care of dubious and uncertain data, ii) Real time activity, iii) Easy blend and coordination of different practices, iv) Ability of creating discernment activity based methodologies, and v) Easy execution. Nonetheless, fluffy route strategies fizzle in neighborhood least circumstances; they have pools of self tuning and self-association and trouble of rule disclosure from master information. [70]

As per the extensive presentation of the fluffy rationale control, if we get the chance to continue our journey of studies and make our doctorat in the field we will plan and assess the ongoing exhibition of various sorts of fluffy thinking and defuzzification techniques on different parts of robots control.

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Abstract

Evolutionary robotics aims to design machines capable of continuously learning new skills in a continuous, uncontrolled and changing world. Based on this observation, Our work offers a non-exhaustive vision of the research themes associated with the field of mobile robotics, and presents the scientific obstacles that remain to be lifted to lead to the development of an autonomous robot. The autonomy of the latter requires the coordinated achievement of tasks of control and perception of the environment. Among these, navigation plays a fundamental role in the interaction of the robot with its evolutionary environment. It consists of the determination of trajectories achievable by the robot to follow a pre-established path, while bypassing mobile or fixed obstacles. To perform this task, our approach is based on fuzzy logic. The navigation problem is then modeled in the form of planning a path for the mobile robot to move from a starting point to an arrival one safely by avoiding obstacles if there is . The obstacles are integrated in the form of constraints by penalizing the movement of the robots; the goal being to allow these robots to change position while avoiding obstacles. Our approach has been implemented and several scenarios have been tested.

Keywords: Mobile Robot, , fuzzy logic , Path Finding, Obstacle Avoidance

Résumé

La robotique évolutive vise à concevoir des machines capables d'acquérir en permanence de nouvelles compétences dans un monde continu, incontrôlé et changeant. Partant de ce constat, Notre travail offre une vision non exhaustive des thèmes de recherche associés au domaine de la robotique mobile, et présente les obstacles scientifiques qui restent à lever pour aboutir au développement d'un robot autonome. L'autonomie de ces derniers passes par la réalisation coordonnée de tâches de contrôle et de perception de l'environnement. Parmi celles-ci, la navigation, joue un rôle fondamental dans l'interaction du robot avec son environnement évolutif. Elle consiste en la détermination de trajectoires réalisables par le robot pour suivre un chemin préétabli, tout en contournant des obstacles mobiles ou fixes. Pour réaliser cette tâche, notre approche est basée sur la logique floue. Le problème de navigation est alors modélisé sous la forme de la planification d'un trajet pour que le robot mobile se déplace d'un point de départ à un point d'arrivée en toute sécurité en évitant les obstacles s'il y en a. Les obstacles sont intégrés sous forme de contraintes en pénalisant le mouvement des robots ; le but étant de permettre à ces robots de changer de position tout en évitant les obstacles. Notre approche a été mise en œuvre et plusieurs scénarios ont été testés

Mots clés : Robot mobile, logique floue, recherche de chemin, évitement d'obstacles

ملخّص

تهدف الروبوتات التطورية إلى تصميم آلات قادرة على التعلم المستمر لمهارات جديدة في عالم مستمر وغير متحكم فيه ومتغير. بناءً على هذه الملاحظة ، يقدم عملنا رؤية غير شاملة لموضوعات البحث المرتبطة بمجال الروبوتات المتنقلة ، ويعرض العقبات العلمية التي لا يزال يتعين رفعها لتؤدي إلى تطوير روبوت مستقل. يتطلب استقلالية هذا الأخير الإنجاز المنسق لمهام التحكم وإدراك البيئة. من بين هؤلاء ، يلعب التنقل دورًا أساسيًا في تفاعل الروبوت مع بيئته التطورية. وهو يتألف من تحديد المسارات التي يمكن للروبوت تحقيقها لاتباع مسار محدد مسبقًا ، مع تجاوز العوائق المتنقلة أو الثابتة. لأداء هذه المهمة ، يعتمد نهجنا على منطق غامض. ثم يتم نمذجة مشكلة الملاحة في شكل تخطيط مسار للروبوت المتحرك للانتقال من نقطة البداية إلى نقطة الوصول بأمان عن طريق تجنب العقبات إذا كان هناك. يتم دمج العقبات في شكل قيود من خلال معاقبة حركة الروبوتات ؛ الهدف هو السماح لهذه الروبوتات بتغيير موقعها مع تجنب العقبات. تم تنفيذ نهجنا وتم اختبار العديد من السيناريوهات.

الكلمات المفتاحية : روبوت متحرك ، منطق غامض ، اكتشاف المسار ، تجنب العقبات

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