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System Development of an Autonomous Lawnmower System Using Ardupilot Mission Planner

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Abstract: This research focusses on the development of an autonomous system for a lawnmower, abandonment of cutting grass due to Covid-19 that impacts the social interactions between humans. Hence, by building an autonomous lawnmower, less worker leads to less interactions between humans that will also save time and labour cost. The main objective is to build simulate an autonomous system using Ardupilot Mission Planner by studying the system and choosing the best solution. This research will fully be conducted using Ardupilot Mission Planner as its system and the simulation. This research are conducted to run a grid pattern for lawn mowing.In conclusion, this research will resulted the effectiveness of different grid pattern and several data gathered from several parameter. Some recommendation for future works is to do experimental testing in real life and for simulation is to include environmental factors to achieve more precision result.

Keywords: Autonomous, Lawnmower, Ardupilot, Mission Planner, SITL.

1. Introduction

An autonomous lawnmower is a self-contained, self-powered, and self-navigating lawn mower designed primarily for lawn mowing repetitively without the supervision of human beings. The autonomous lawn mower is a vehicle consist of cutting element, gas engine, electric drive motor and systems, sensors, and structural chassis. The device will automatically cut the grass along its path that has been programmed. The path is a mapped geometrical field that is tracked by using pinpoints and virtually made fences to build the cutting area. The sensors are then is used to track any foreign object to avo Pandemic Covid-19 causing many activities among human requires a new approach. For the very first time, the introduction of Movement Control Order (MCO) causing no work can be done during this period. The abandonment of cutting grass work in the football field let the grass grow uncontrollably for a few weeks. Here there is a need to have an autonomous lawnmower system to avoid such interruption of service.

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The introduction of autonomous lawnmower may reduce dependencies on human labor works where the machine can work continuously without break and at any time day or night. Cost of field maintenance also maybe reduce where we only focused on the machine maintenance without bothering about labor wages and others.id colliding and re-track itself to complete the desired cutting area.

The objective of this study are to simulate an autonomous lawnmower system and to apply Mission Planner features such as fences and missions to build an autonomous system. The significant of study are helping future development on autonomous lawnmower, highlight the advantages of autonomous lawnmower and implement other research towards an autonomous system.

1.2 Additional introduction subheadings

Subheadings in the introduction are usually limited to 2-3 topics. Contents should be brief; more detailed information should be discussed in the methodology section.

2. Materials and Methods

In this chapter, the topic that will be discussed is about the methodology of simulating the autonomous lawnmower Ardupilot Mission Planner SITL. There is some information that needs to know before starting the build. All procedures of this project will be explained in detail. This chapter also discussed about the fence and mission setup, frame type selection and parameter collection. SITL or System In The Loop allows to run Ardupilot without having any hardware

2.1 Materials

. The materials that are used during this research are Ardupilot Mission Planner and the system that replaced the hardware of the rover that is System In The Loop (SITL).

2.2 Frame type selection.

The frame type of this case of study is based on the 4-wheel robot, if the frame fails to conduct the study fairly the framework for this project will be reselect maximum input for our sensors and motor to work properly. For the basics, the frame of this project will based on 4 wheeled rover frame. The frame resembles the actual lawnmower rover which is 4-wheel and one motor servo steering.

Table 1: Table of vehicle type in Ardupilot Mission Planner SITL

Item	Vehicle	Frame type
1	Plane	Plane, quad plane, firefly, plane-dspoilers, plane-elevon, plane-jet, plane-tailsitter, plane- vtail, quadplane-cl84, quadplane-tilthvec, quadplane-tilttri, quadplane-tilttrivec, quadplane-tri
2	Copter	Quad, coaxcopter, dodeca-hexa, heli, heli-compound, heli-dual, hexa, hexa-cwx, hexa-dji, octa, octa-cwx, octa-dji, octa-quad, octaquad-cwx, tri cwx, singlecopter, y6, djix
3	Rover	Rover, balancebot, rover-skid, sailboat, sailboat-motor

The selection of frame type is crucial for the system to load the correct parameter set. Hence, from the Table above the correct frame type selection for the research is the rover and in the rover system. This will load a one motor servo steering frame type.

2.3 Home location

Home location setup can be done in two ways. One of the way is dragging the home location icon to the desired location. This procedure is easy to access and user friendly. The downside of this procedure is if the default location is far from the targeted area, finding the targeted location and dragging the home location will be tough as the targeted area should be search first before dragging the home location in the world map

The other way to set home location is by calling sim_vehicle.py with a parameter that is called "-L" and a named location ardupilot/Tools/autotest/locations.txt file. Location file could be upload using location text.

2.3 Fence setup

Before waypoints are build, geo fence is built in the SITL to make sure the rover stays within the desired area. In this simulation, it will be assigned at the UTHM football field. Several steps is taken to make the fence included. First off all in the plan tab, draw a polygon on the desired area. Choosing the "draw a polygon" menu will automatically lead to where waypoints of fence can be clicked to make a polygon. After that, the fence inclusion is clicked to include the fence on the mission. The waypoints of fence will be turned blue that signals that the fence are included. Lastly, to check whether the fence is included, the config tab is clicked and to the full parameter list then searched the fence option. The fence action and the fence enable is checked if the value is 1 the fence have successfully included if the value are 0, it has to be change to 1.

2.3 Mission waypoints setup.

The setup of the mission waypoints has the similar process with building the fence with an extra step. In the plan tab, the menu is changed to mission. Next, the polygon is drawn within the desired area. The next step is the extra step that have to be included. The polygon is used as a guide to build grids of waypoints. Waypoints can also be built without using a polygon but the polygon gave an extra feature that can make equally lines by setting its distance between line.

3. Results and Discussion

A detailed discussion has been made based on the results obtained from the simulation that is available and listed in the scopes of study. All the results obtained are based on the geometrical fence settling, grid pattern analysis and data collection from various parameters.

3.1 Fence settling

Fence in autonomous system is really used to avoid foreign object or walls. Fence are also a feature in Ardupilot Mission Planner that can be easily access. The fence is drawn using a polygon and included in the mission. The data is collected after several attempts of forcing the rover to go over the fence and using waypoints outside the fence to observed its reaction towards the fence.

There are some problems faced when building the fence. The waypoints of a mission cannot be outside the fence, as the rover will stuck at the fence and stopped due to trying to reach the mission waypoint. Home point also must be inside the fence. If the home point inside the fence the rover will not automatically follow the mission waypoints as it reads the rover are outside the fence boundary.

3.2 Grid pattern analysis

Several pattern can be made to cover the desired area. The patter is straight grid, cross grid, corridor grid and spiral grid. These pattern will influence the number of waypoints and the estimated time. Furthermore the data of the simulation such as battery percentage and gap between waypoints also will be differ.

Table 2: Table of grid pattern, number of waypoints and extimated time taken

Pattern	Number of waypoints	Estimated time taken (min)
Straight grid	68	7.57
Cross grid	168	14.48
Corridor grid	150	25.13
Spiral grid	36	8.25

In conclusion, Straight grid is the best pattern among the other pattern because Straight grid pattern have the least estimated time taken to complete the mission. Straigh grid pattern lowers the possibility of overturning where the rover only takes several short turns between the lines.

3.3 Data collection from various parameters

After the selection of grid have been made, the simulation is done using the grid. There are several parameters that can be observed. The parameters are the latitude and longitude of the waypoints, battery percentage and the curvature of the rover's turning between turns.

Table 3: Data collection from the simulation

Waypoints	Latitude	Longitude	Reached	Battery (%)
Home	1.8536508	103.085117	Success	100
2	Data Point 2	1.000	Success	79
3	Data Point 3	1.0×10^{4}	Success	61
4	Data Point 4	-1.0×10^{-4}	Success	58

In conclusion, without considering the weight and mechanism of a real product. The system of an autonomous lawnmower using ardupilot and pixhawk can successfully detects its direction to the waypoints given. There are several adjustments that have to be made for the rover to cover all the cutting area that are not covered due to overturning. Using Mission Planner also provides latitude and longitude of waypoints. In a single mission that have been conducted, the system of an autonomous lawnmower could retain its battery percentage until the end. The voltage and also the ampere are consistent throughout the mission

4. Conclusion

An autonomous system lawnmower can be built using ardupilot Mission Planner. The Ardupilot Mission Planner have various kind of feature that can be used to build an autonomous system. The Mission planner not only supporting air vehicles, it also supports rovers, sailboats and multi rotors air vehicles. Fence in the Mission Planner can be built easily because of the Mission Planner user-friendly interface. The fence is used to control the rover to not cross the desired area and to avoid colliding to objects or walls that are not clarified into the Mission Planner system. The fence also will not allow the rover to turn exceed the fence. The problem faced when the fence is built is the waypoints must be

within the fence, whereas the rover will stop at the line of fence and will not reach the waypoints. The rover also will not correct itself to ignore the restricted waypoint and go to the next waypoints. Grid patterns also influence the performance of the rover. However, grid pattern is restricted to the users itself where the users may desire different cutting patterns. Straight grid pattern may be not had the least waypoints but the structure and path of the grid makes it has the shortest estimated time taken. For autonomous system that only considering the system without the considerations of the actual weight and properties of the rover, the system may survive a full mission that takes a whole field of the UTHM football field with the remaining 58%.

Some recommendation for future works are an experimental testing method should be conduct in real life to consider environmental factors and real parameters to have an exact data of the testing. Next, the over turn of the rover when turning should be considered primary to make sure all area of the grass are completely cutted. Grid pattern should be compared with more detail to collect data whether the cutting area are fully covered and the patterns that each grid makes. Furthermore, environmental factors should be considered when doing simulation to gather more accurate data. Lastly, waypoints should be added and reduce their gaps more to smooth the rover going through the paths.

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