2019

Autonomous Route and Mapping 2D - 3D Lidar Scanning

FUNCTIONAL SPESIFICATION

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Introduction

The proposed application that is titled “A.R.M. LiDAR System” which stands for Avoidance and Route Mapping LiDAR System. This is intended primarily as a system that will enable potential users to detect objects or obstacles and path find a way around and or through them, mapping as it moves through the environment. This mapping is done via a point cloud map, this is represented as a collection of points in a 3D shape, each point has its own set of X, Y and Z coordinates and in some cases have additional attributes. Connecting a mobile unit to this application should provide the user with a set of parameters where they can control the unit remotely or additionally, it can act autonomously on predefined parameters, then return to the user once complete. Once the MU (mobile unit) is on a route it should map the environment using the LiDAR scanner, this will give a 2D or 3D map of the area depending on the capability of the scanner. Using this data, we will be able to see the MU’s point of view and map of the area it passed though and objects it avoided.

Functionality Specification

1. Avoidance Algorithm

The application will have a visual representation of what the LiDAR scanner can see in full 360-degree points of data. Utilizing this data in the avoidance algorithm will allow for the scanner to see objects that get closer, this is represented as large consistent lines or 3D shapes in the point cloud map. The role of this algorithm is to determine if an object is too close and what to do once it has detected an object within a certain distance. This will allow the application to analyse each object, the speed that it is moving towards the LiDAR scanner and the estimated time of impact. If these criteria are met, the application should produce a warning to the user and give appropriate directions to move around the object or to stop altogether.

2. Route Planning

The user will be able to create custom routes within the application. The MU (Mobile Unit) will be able to operate on these predefined parameters and avoid obstacles along the way. Alternatively, the user can select a route from a list of successfully completed routes and edit the route settings i.e. last run or the change the start time.

3. Mapping

As the MU (Mobile Unit) is moving, it should be represented to the user as a point moving through an unmapped area. Not unlike radar LiDAR maps the environment as it scans the area bouncing laser pulses, with full 360-degrees of vision, back and forth to create a mesh of point data to create a 3D model.

4. Mobile Unit Connection

It is necessary that the application is capable of receiving the MU data. The application should be capable of sending data like routes to the MU. In order to do this, the MU will need to be identifiable to the system as a ground unit, so it can be paired to the controller. This will be able to issue commands to the MU and receive MU map data once paired. This controller should be identified as an interface between the MU system and the application.

5. Mobile Unit Control Algorithm

It is important for the user to have the ability to create routes via plotting points on a map for the MU to follow. Once the route is entered the application should be able to handle the new routes information and allow the MU to path-find its way through the environment. The controller should be able to ensure that the MU takes the best path avoiding obstacles along the way.

6. Data Storage

The logistical map data from each route should be stored in order for the user to get a full object map of the environment in which it is operating. This should happen each time the application starts as it needs to “see” what is around the unit. Stored map data should be available from the database if requested, and routes on that map data should be stored to be used later.

Target Audience

The intended market for this software is emergency services that need better solutions for rescue operations. For example;

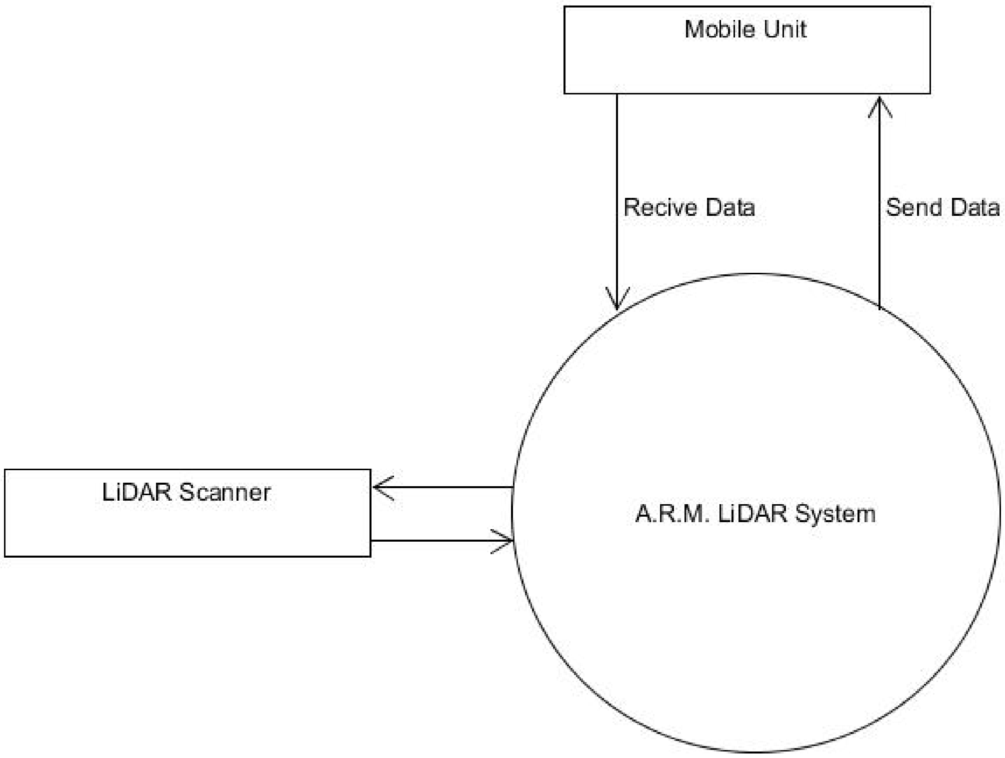
Emergency services who rely on the ability to map dangerous areas with exact measurements to determine whether a collapsed building is structurally sound enough to send servicers in to rescue potently trapped civilians.

City services could avail of this application as having an autonomous ground or water drone could help with potential mapping of underline issues with the integrity of sewerage systems or other underground amenities with unideal human conditions e.g. lighting, tight or hard to reach places.

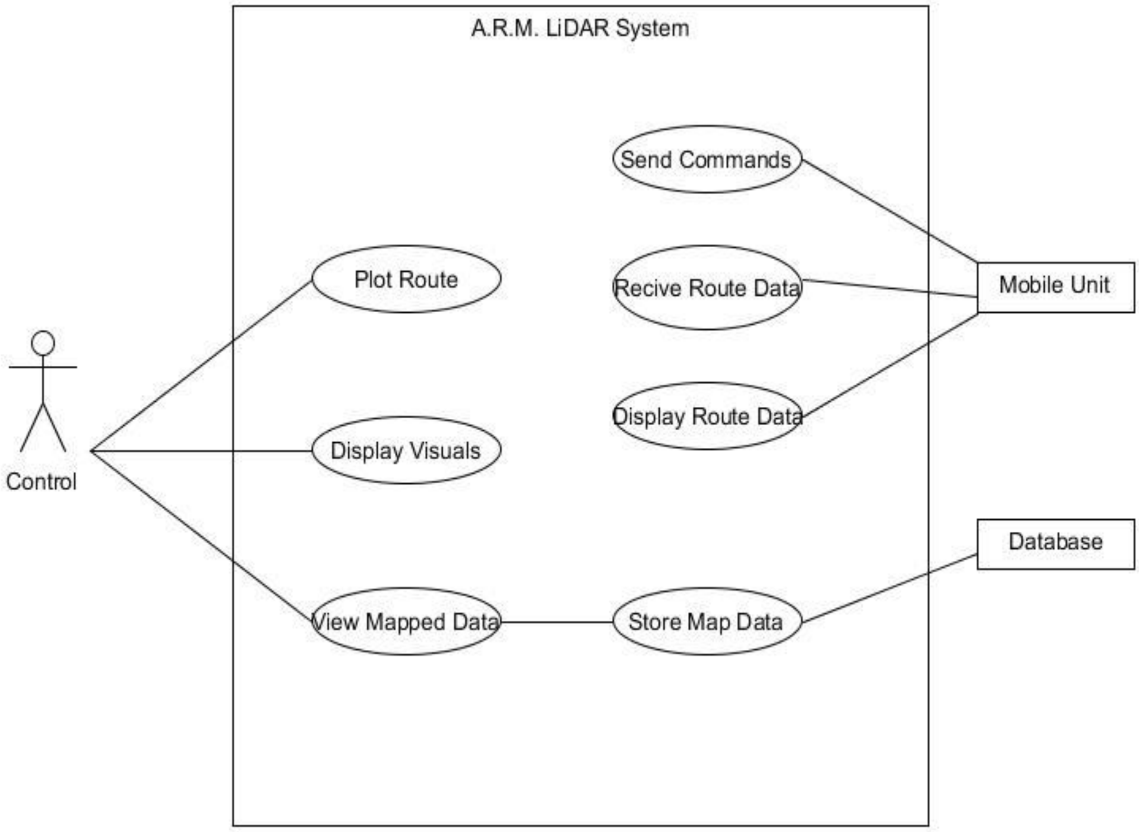
Automated security utilizing this application could prove useful as LiDAR is very discrete unlike cameras, it will not need ideal lighting situations to operate effectively. However, this would only be the application that maps and detects differences predefined by the user, so it would be great to see anything that was not previously there.

This could also be utilized in other areas like the farming sector that need to map farmland and find any potential hazards for livestock, this could be anything ranging from holes in the ground or broken fences that livestock could get out though or hurt themselves on.

Context Diagram



Use Case Diagram



Use Cases

Use Case UC1: Plot Route

Primary Actor: Controller.

Stakeholders & Interests:

Controller - wants to create, view, edit or remove a route from the system.

Preconditions:

MU that currently has an unassigned route.

Success Guarantee:

A route plan has been generated, modified, viewed or removed.

Main Success Scenario:

1. The user wants to examine the existing routes.
2. The user selects "Manage Routes"
3. The system presents the user with a list of currently assigned routes with options to create a new route, edit an existing route or delete a route.
4. The user selects a route for viewing.

Alternate Flows:

Use Case UC2: Display Visuals

Primary Actor: Controller.

Stakeholders & Interests:

Controller - wants to view the environmental data from the LiDAR scanner.

Preconditions:

LiDAR is sending data to the application.

Success Guarantee:

Controll can see the visualization of the LiDAR.

Main Success Scenario:

1. The user wants to examine the existing routes.
2. The user selects "Manage Routes"
3. The system presents the user with a list of currently assigned routes with options to create a new route, edit an existing route or delete a route.
4. The user selects a route for viewing.

Alternate Flows:

Use Case UC3: View Map Data

Primary Actors: Control, Database

Stakeholders & Interests:

Control - wants to view map data.

Preconditions:

At least one route has been completed by an MU.

Success Guarantee:

The user is presented with the map data.

Main Success Scenario:

1. The user wants to view the completed MU routes.
2. The user selects the "Display Route Data" option.
3. A query is sent to the database to fetch the most recent route data.
4. The results of the query are displayed to the user.

Alternate Flows:

Use Case UC4: Store Map Data

Primary Actors: Controller, Database

Stakeholders & Interests:

Controller – keeps a record of completed routes.

Preconditions:

MU has passed the check, MU has been assigned a route, MU has completed the assigned route.

Success Guarantee:

Successful route map data has been written to the database.

Main Success Scenario:

1. The MU has completed its assigned route.
2. The system writes the map data of the route to the database.

Use Case UC5: Receive Mobile Unit (MU) Data

Primary Actors: Mobile Unit

Stakeholders & Interests:

Controller - needs a connection between MU and application.

Preconditions:

The MU must be sending and receiving data.

Success Guarantee:

The MU will respond to simple commands from the application.

Main Success Scenario:

1. The MU is receiving data from the system.
2. The MU Controller has connected to the MU.
3. The MU Controller issues a check to verify the MU can receive commands.
4. The MU responds with the data necessary for the check.
5. The output of the check is written to a log file.
6. MU Controller requests MU scanner data.
7. MU sends scanner data.

Alternate Flows:

4a. The MU does not pass the check.

4b. The results of the check are displayed on the application.
4c. The results are written to a log file.

7a. The MU does not send scanner data.

Use Case UC6: Display Route Data

Primary Actors: Controller.

Stakeholders & Interests:

Controller - wants to view the route data for MU.

Preconditions:

MU has passed the check, MU has been assigned a route, MU is currently on route.

Success Guarantee:

The user can see the route assigned to the MU.

Main Success Scenario:

1. The user selects the MU.
2. The user selects “View Route Data”.
3. The route associated with the MU is displayed alongside the map data.
4. The user clicks the “Close” button

Alternate Flows:

4a. The user does not click “Close”.
4b. The route data remains open until the MU has completed the route.

Metrics

- The application should run on (desktop, laptop).
- The application can send and receive data from the LiDAR and ensure that the MU can be given commands.
- Map data can be seen in real-time as the MU follows the route.
- The user can maintain routes.

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*I have provided a complete bibliography of all works and sources used in the preparation of this submission.

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