Arnab Chattopadhyay
Kaarle Patomäki
Sampo Simolin

Title, introduction and drafting of the paper

Three candidates for title:
1) LIDAR automated crane system
2) Autonomous warehouse management
3) Automated Indoor factory floor material management system

Introduction section:
Overhead cranes are used widely in industry for cargo handling. They are usually being handled by an operator, who has a controller to move the crane. Handling an overhead crane can potentially be dangerous for surrounding people without proper precautions, and even with high safety regulations accidents do happen. Cargo handling as a business has tight business margins, and every way of improving the economic efficiency is welcome to the business.

This study is focusing on those aspects of overhead cranes: improving safety and the efficiency of cargo handling with an overhead crane. This is done by studying the possibilities of making an overhead crane autonomous. There has been research on autonomous crane operation already in warehouse and other environments (1, 2, 3). These articles describe methods for collision detection and trajectory planning. In this study, however, a lidar (light detection and ranging) is used as the main tool for the automation to achieve excellent reliability, efficiency and safety with heuristic and dynamic self-control by the crane. Laser scanners have been previously used for improving visibility of the crane operator (4, 5) and also for other path-planning applications, including UAVs (6), but not for providing data of the environment for autonomous crane operation. Research on using point cloud and building a 3D map of the environment has been done, and it is applied to this study (7). Also, there is a lot of research done on trajectory planning, and there should be enough information and algorithms to make this part of the project work even in uncertain situations (8) (9). Path planning is possible to apply even in dynamic situations, where environment changes (10).

Methods
In the methods chapter we discuss the process of how we got from the start of the project to a final design and demo model. The idea process, design process and building process are discussed trough.

System contains an overhead bridge crane, that can be programmatically controlled, SICK Lidar for detecting surroundings, a rig for holding the lidar on the crane trolley and allowing it to move/rotate in a way that surroundings are detected in a satisfying level of precision, Raspberry pi 3 for data handling and possibly another computer for heavy real time calculations. All parts of the system are connected to same wireless local area network, except lidar is connected to the Raspberry Pi with ethernet cable.

Our main objective is to automate the crane by implementing object collision detection and trajectory planning. To implement that, one fundamental part of the system is the interface between the LIDAR and the crane: Python was used to automatically control the crane's movements whereas the data processing of the LIDAR was done on a standalone C# application developed by us. Based on the analysed LIDAR data, information about the next direction was sent from the C# application to the Python application.

The analysis of the point cloud obtained from the LIDAR was also done using a __ algorithm to generate the objects from the raw point cloud data. A trajectory planning algorithm __ was also implemented to divide the room into grids and to make decision regarding the next grid to move based on collision avoidance data and the final destination coordinate.

For the mounting design of the crane: the LIDAR was placed with its field of view facing downwards and a rotational degree of freedom was given to it to rotate about an axis perpendicular to the ground. The placement of this mounting was done on the trolley so that it could be close to the payload and also obtain power from the trolley.

Results

Our final product is a system which comprises of hardware and software components which help in making a LIDAR automated crane system.

Our systems comprised of:

The mounting of the LIDAR, standalone software application for LIDAR data processing and application to instruct the crane about the direction of travel and next coordinate.

Tests on System:

Our system was designed for the ILMATAR crane which has a payload capacity of 2 tonnes and for our testing we chose a payload of size ___ and designed a system which could detect a test obstacle of ___ dimensions and above at a distance of __.

Performance on the tests:___

Discussion

Pros and cons of using this system, potential of the system, how general can the automation be designed as or if it has to be designed one case at a time. Assumptions made while designing our systems and possible changes needed to make it a real time system

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