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:
Automated cranes have been developed a lot since robots have become more general. That's why there are many scientific articles discussing the use of automated crane systems in warehouse (1) and other environments (2, 3). These articles also describe methods for collision detection and trajectory planning. These are very advanced systems, but our idea is to use a laser scanner for scanning the environment and using the point cloud for dynamic detection of environment, collision avoidance and trajectory planning. 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. Using point cloud for building 3D map of environment is also quite common practice and there are a lot of research based on algorithms and methods for doing this (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)

This research is done because collision avoidance makes crane operation safer for everyone. Also there are cost savings if no crane operator is required to operate the crane. For these reasons we are going to combine automated crane operation with laser scanner to achieve even better and safer automated crane operation. This project will show that how realistic is the idea of using a lidar to dynamically scan surrounding of a overhead crane, and how reasonable, safe and cost efficient this is. Crane manufacturers might be quite interested in the results of this research.

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.

There are still some questions on how certain parts will be implemented. Our lidar has a field of view of 120 degrees horizontally and 15 degrees vertically. This is why attachment of the lidar is not yet completely decided. It might be that it ‘sees’ enough if it is statically installed in the crane trolley, or it might need rotational or linear movement. This is something that we have to test in the following weeks.

We also have to test if Raspberry pi 3 has such performance that it can handle real time calculations (parsing of raw lidar data, path planning, collision detection and actually moving the crane). If it doesn’t then we can sent raw lidar data to another computer via WLAN and do data processing there. This is also something that we are going to test in the following weeks; see what kind of latency we get if Raspberry pi is doing the calculations and make decisions based on that.

Results

In the results chapter the final product is presented and it’s working principle is explained thoroughly.

Discussion

Finally, in the discussion chapter we look back at our goals and determine whether we have succeeded in them. We also discuss whether we succeeded in the competition.

References:

1: liver Sawodny, Harald Aschemann, Stephan Lahres, An automated gantry crane as a large workspace robot, Control Engineering Practice, Volume 10, Issue 12, 2002, Pages 1323-1338, ISSN 0967-0661, https://doi.org/10.1016/S0967-0661(02)00097-7. (http://www.sciencedirect.com/science/article/pii/S0967066102000977)

2: Sivakumar, P. L., Koshy Varghese, and N. Ramesh Babu. "Automated path planning of cooperative crane lifts using heuristic search." *Journal of computing in civil engineering* 17.3 (2003): 197-207.

3: ShihChung Kang, Eduardo Miranda, Planning and visualization for automated robotic crane erection processes in construction, Automation in Construction, Volume 15, Issue 4, 2006, Pages 398-414, ISSN 0926-5805, https://doi.org/10.1016/j.autcon.2005.06.008. (http://www.sciencedirect.com/science/article/pii/S0926580505000713)

4:Cheng, Tao, and Jochen Teizer. "Modeling tower crane operator visibility to minimize the risk of limited situational awareness." *Journal of Computing in Civil Engineering* 28.3 (2012): 04014004.

5:Cheng, Tao, and Jochen Teizer. "Crane operator visibility of ground operations." *Proceedings of the 28th ISARC* (2011): 699-705.

6.Hrabar, Stefan. "3D path planning and stereo-based obstacle avoidance for rotorcraft UAVs." *Intelligent Robots and Systems, 2008. IROS 2008. IEEE/RSJ International Conference on*. IEEE, 2008.

7. Zhang, Chi & Wang, Junzheng & Li, Jing & Yan, Min. (2017). 2D Map Building and Path Planning Based on LiDAR. 783-787. 10.1109/ICISCE.2017.167.

8. Janson, Lucas, Edward Schmerling, and Marco Pavone. "Monte Carlo motion planning for robot trajectory optimization under uncertainty." *Robotics Research*. Springer, Cham, 2018. 343-361.

9. Kelley, John Joseph, Nathan Eric Bunderson, and Daniel John Morwood. "Path planning system for a work vehicle." U.S. Patent Application No. 15/627,303.

10. Hu, Xuemin, et al. "Dynamic path planning for autonomous driving on various roads with avoidance of static and moving obstacles." *Mechanical Systems and Signal Processing* 100 (2018): 482-500.