High precision positioning at large facilities,

in a collaboration with project B.O.R.I.S.[1]

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Large-scale infrastructures, such as MAX IV Laboratory, depend on equipment that is required to perform highly precise work. Such performance is strongly affected by the components´ position in space. The goal of this project is to develop an advanced robot that will bring the precision of equipment positioning to a level far beyond the one attainable by current methods. MAX IV and its collaborators and users from academia and industry will greatly benefit from the project outcome. Furthermore, the robot could be used in other similar environments and has a potential for application in industrial setups.

High precision positioning at MaxIV is provided by a laser tracker, the main connection between network (coordinates of reference points inside the facility) in a 3D CAD model and reality.

State of the Art

MAX IV is the Swedish synchrotron facility currently counting with 14 beamlines hosting approximately 1000 users/year, being the brightest of its kind and developing further on the forefront of synchrotron science. Currently, the installation of all equipment at MAX IV is supported by bluelining, a technique for transferring a three-dimensional computer model into real space to make marks for equipment installation on the floor[2]. Measurements are provided by a laser tracker and the received data stream is analyzed by the engineer. It is a manual process with the main disadvantage of being sensitive to operator´s errors: an error of a few millimeters in positioning can have devastating consequences on the final equipment installation, alignment and performance, lacking the required precision.

Moreover, the process is time consuming and physically demanding, as the engineer has to crouch on the floor for marking. Advancing from a manual to a fully automated, highly precise system would improve the method significantly. There are a few interesting solutions for mobile

[1] B.O.R.I.S - Bluelining Optimal Robotic Imprinting System. (Bluelining is a technique of transferring a three-dimensional computer model into real space to make marks for equipment installation on the floor)

[2] A review on application of laser tracker in precision positioning metrology of particle accelerators, Vikas, Rajesh Kumar Sahu, Precision Engineering, Volume 71, 2021, Pages 232-249, ISSN 0141-6359

floor marking systems and drawing robots[3,4], but the required accuracy and precision for positioning was not suitable for MAX IV.

Furthermore, at MAX IV we aim to use the same measurement methods for bluelining, alignment and network survey to maintain the integrity of the system and the ability to track its state.

There are many possible subjects for Master Thesis, courses or internship at MaxIV within the following areas:

1. Development of a robot which confidently copes with the task with high accuracy and precision. The robot will mark the floor and/or scan flat surfaces with respect to the global coordinate system of MaxIV. The expected positioning accuracy is **below 0.1 mm**, the expected marking accuracy is **1 mm**.

2. Adaption of the existing suitable to the task robot:
   - Receive the data stream with coordinates via UDP
   - Analyze your position in the facility by using installed sensors and laser tracker
   - Get the target for marking / Get the area for scanning
   - Perform the task with high accuracy and precision

B.O.R.I.S.

Preliminarily, we have developed a high-precision self-positioning robot[5] that simplifies the work by automatically driving to the location specified by a computer and marking that position with a dot and lines. The concept has shown promising results, that led us to prototyping.

The prototypes "zero" and "one" are currently used for several educational activities at Lund University[6], but further development will allow real-life application in floor scanning and positioning of equipment at upcoming MAX IV beamlines.

The expected marking accuracy is below 1 mm with the standard pencil, the expected positioning and scanning accuracy is below 0.1 mm.

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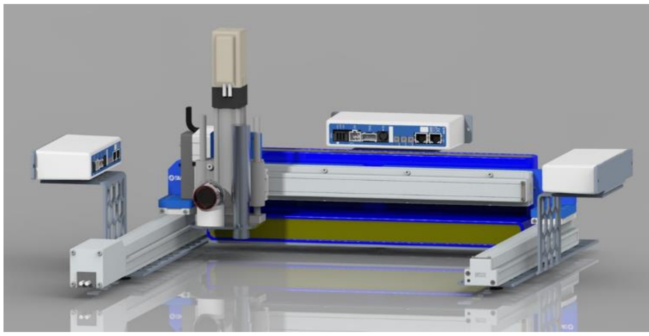
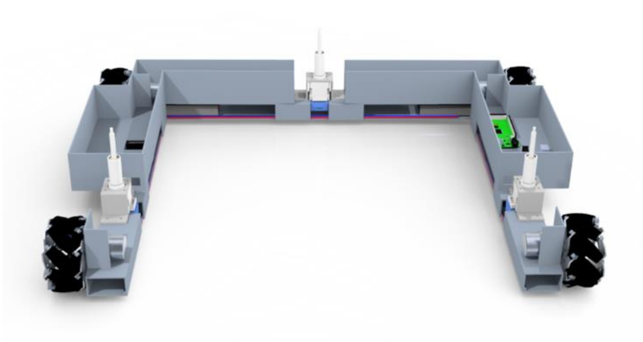
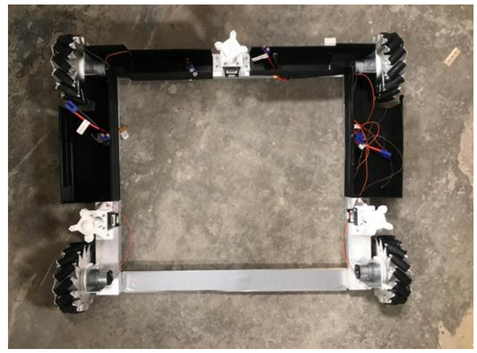
[3] "A mobile robot system for automatic floor marking", Jensfelt Patric, Gullstrand Gunnar, Forell Erik, 2006 (English)In: Journal of Field Robotics, ISSN 1556-4959, Vol. 23, no 07-jun, p. 441-459

[4] "Mobile robot for marking free access floors at construction sites", Takehiro Tsuruta, Kazuyuki Miura, Mikita Miyaguchi; Automation in Construction, Volume 107, 2019, 102912, ISSN 0926-5805.

[5] "Mobile Floor-Marking Robot, utilizing Feedback from Laser Tracker", Master Thesis, Klinghav Lisa, (2021) Department of Automatic Control

[6] LTH courses: EIEN45, EIEN01, FRTF20, FRTN70, IYT000, The Master Thesis by Lisa Klinghav; EU Robotics Week 2020 together with LTH



Project Partners / Contributors

The project for the development of the current prototypes has been led at MaxIV Laboratory by Alina Andersson (research engineer in SAM-team, Engineering I). The department of Automatic Control, LTH, Lund University and the division of Industrial Electrical Engineering and Automation, LTH, Lund University will be involved in the further developments described in this application.

The project keeps an active collaboration and knowledge sharing with the SBUF development project by Peab, Cognibotics AB and LTH (Buster - construction robot dog based on Spot from Boston Dynamics). MaxIV Laboratory can provide the network and tools for positioning, as well as industrial supervision for students in the corresponding projects.

References at LTH

If you have any questions about the academical part of the project and courses, you may ask:

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