NEED A HELPING HAND?

DEVELOPMENT OF A SCREW REMOVAL ROBOT

SUMMARY

In Japan, building interior renovation commonly requires construction workers to remove self-tapping screws from suspended ceiling beams by hand. This is a long and physically demanding process. It is, however, simple and repetitive, making it ideal for automation.

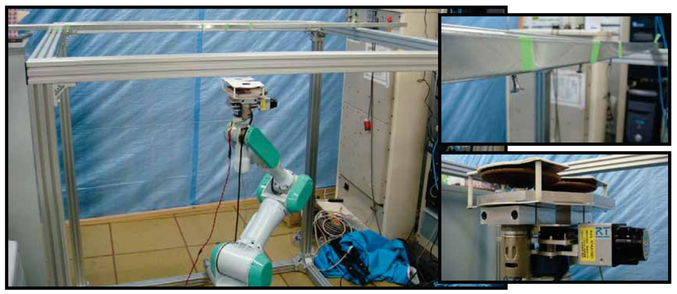
A ceiling beam screw removal robot is proposed for the screw removal step. We also present a safe and novel simulation environment for the development of the robot. The simulation environment is able to reduce development cost, improve efficiency, and ensure safety for the robot developers during the development process, as well as for training end-users in operating the robot to remove screws.

BACKGROUND

Japan, like most industrialised countries, is facing the growing problem of an aging population, which results in a decline in the availability of skilled workers. Robots are a natural source of potential replacement labour.

At the same time, the rising cost of raw materials and an increasing awareness of the environmental impacts of human activities have created an increasing focus on recycling materials wherever possible.

Rather than cutting or pulling the screws from the beam, which damages both the screws and the beam, a robot manipulator system is designed that takes a more sustainable solution, using a custom screw removal tool to unscrew the screw, leaving the materials in a reusable condition.



Test setup for the screw removal robot system.
Right: Ceiling beam with screws, and the custom screw removal tool.

MIXED REALITY SIMULATION

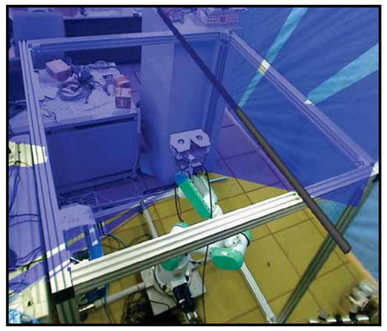
The main technology that drives the development of the screw remover robot system is Mixed Reality Simulation. Mixed reality simulation integrates virtual components into a real experimental setup to provide a safe and cost-effective solution for experimenting with complex robot systems.

Prior to the introduction of the mixed reality simulation technology, beams and screws were damaged by this powerful robot manipulator during development. There were also concerns about the operator's safety in deployment.

Solution: A mixed reality simulation environment is created for this project. The simulation involves a **real robot manipulator** removing **virtual screws** attached to a **virtual ceiling beam**.

The real robot manipulator is able to detect the virtual ceiling beam with its laser, detect contact between it's end-effector and the beam, and slide along the beam to remove the virtual screws attached to the beam.

This greatly helped to minimise the overall development cost and speed up the development process.



An Augmented Reality (AR) view of the robot in action.
The virtual ceiling beam is shown placed over the robot.

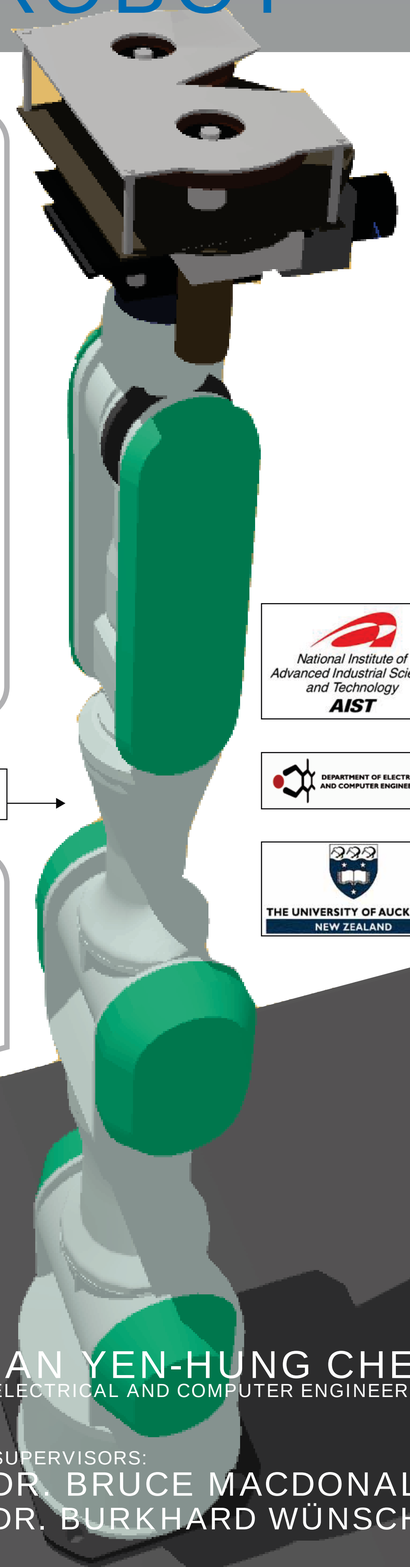
ROBOT SYSTEM

Robot
(Mitsubishi PA10 300)
7 degree-of-freedom industrial robot manipulator.

Custom Screw Removal Tool
Attached to the end-effector of the PA10 robot manipulator for removing screws from beams.

Force-moment Sensor
(Nitta IFS-67M25A25-I40)
Mounted below the custom screw removal tool for detecting contact between the screw removal tool and the beam.

Laser Sensor
(Hokuyo URG 04-LX)
Mounted on the side of the screw removal tool for detecting the beam over the robot on initialisation.



Mitsubishi PA10 Industrial Robot Manipulator
installed with a custom screw removal tool

RESULTS

In our experiment, the developed robot system successfully removed multiple screws from a sample ceiling beam.

The mixed reality simulation environment created was found to produce robot movements that accurately represent the robot behaviour in the real world, showing a root mean square error of 1.10%.

On the other hand, a user study investigated how well the simulation environment was able to train human operators in using the robot. Results reveal that the users are quite positive about the simulation environment and felt that it minimises harm in case of failures. The users also believe the simulation offers a reliable transfer of results to reality.

CONCLUSIONS

We have presented a robot manipulator system that takes a sustainable approach for removing screws from suspended ceiling beams during the building renovation process.

We have also demonstrated the use of mixed reality simulation for the development of the screw removal robot system. The simulation environment created was able to minimise resource requirements during testing by preventing damage to the actual materials when failure occurs.

The results are promising and indicate strong user acceptance to the simulation technology as well as the final robot system

National Institute of Advanced Industrial Science and Technology
AIST

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

ROBOTICS GROUP

IAN YEN-HUNG CHEN
ELECTRICAL AND COMPUTER ENGINEERING

SUPERVISORS:
DR. BRUCE MACDONALD
DR. BURKHARD WÜNSCHE