

Shadow robot

Shadow Robot - Bandsaw cutting of Beef Shank-Stage 1

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Project Description

The project “Shadow Robot, stage 1” is providing the industry with working knowledge on state-of-the-art telemanipulation technologies and their potential applications using cutting of beef shanks as a case. The project has built working knowledge by control of a Universal Robot 10e cobot with two different telemanipulators¹. By using the telemanipulation technology it is possible to remove the human workforce from the hazardous meat processing tasks. It is also possible for operators to work remote on a distance with meat plant operations like cutting beef shanks on a band saw, which was the defined case used to obtain working knowledge in this project stage. The project has also investigated the functionality, accessibility, and user-friendliness of the telemanipulation technologies.



Figure 1. Telemanipulators used in project.

Project Content

The project has focused on:

- Setup/design of the communication and validation for the entire system functionality (cobot, telemanipulator, safety system and end-effector).
- Evaluating the feasibility of the 2 telemanipulation technologies in removing human workforce from the hazardous meat processing tasks, when cutting beef shank on a band saw.
- Develop and demonstrate a methodology using telemanipulators for the task to meet capacity and quality requirements (± 10 mm on a 50 mm thick slide).
- Provide the industry with working knowledge on state-of-the-art telemanipulation technologies and their potential applications.
- Test the user-friendliness of the telemanipulation on the test application, placed in a meat plant environment.

¹ Virtuoso 6D and Viper (Virtuoso with force feedback and Viper without)

Project Outcome

The project managed to set up the communication between the cobot and telemanipulators and develop a validation test for determining the uncertainty in the entire system.

- When the entire Viper system (Viper, robot, and tool) was working at a speed of 5 [cm/s] then the precision was ± 3 [mm]. This was determined by writing straight lines on a flat surface with a pen as the end of arm tool “the 10 line test”
- When the entire Virtuose system (Virtuose, robot, and tool) was working at a speed of 5 [cm/s] then the precision was ± 3 [mm]. This was also determined by “the 10 line test”.

At the current development stage, the Viper system has no force feedback and based on operator experience, this led to focussing on completing the project using the Virtuose system.

After determining that the precision of the entire system was within the tolerance, the actual test of cutting various sizes of beef shanks began. The project succeeded in the last milestones demonstrating a steady consistence in quality for the shank cut samples with an experienced operator controlling the process fully remote. Slices were within the acceptable thickness variation of the specification 50 [mm] ± 10 [mm].



Figure 2. Remote cutting of shanks, monitoring the process on a screen.

The user experience was also tested by 11 untrained users given a short 3-5 min introduction to the setup actions and boundaries as well as the process and a few minutes to accustom themselves to the operator movements using the manipulator handle before the actual cutting. The initial first cut had been made beforehand to provide the user with a good reference. 91% of the untrained operators were able to cut one entire shank within the desired tolerance.

The untrained user feedback was that the 3-dimensional feeling was lacking when the input came from a 2-dimensional screen only, and the force feedback should be supplemented with 3d-audio to make the experience more intuitive and allow for a faster learning and more comfort in controlling the process. This might be supplemented by adding a more 3D or virtual-like environment for the operator.

One project outcome is that a cobot and a telemanipulator at the current technology level is not a perfect match in terms of process stability. The two regulators are not always on the same wavelength regarding the actual position for the cobot. This can cause some unwanted situations. The project concluded that the telemanipulation setup functions better with only one force feedback regulator in the system, rather than both in the Virtuous and the cobot. The preferred setup is more likely to be an industrial robot and a telemanipulator with force feedback.



Figure 2. Cutting of slices in steps, with the actuator both serving as land and to push out the product after cutting.

Benefit for the Industry

Telemanipulator usage in the meat industry is a new approach, here tested in remote cutting of beef shanks. The tests and technology demonstrated learnings and several benefits where application could be feasible.

Remote operations

Taking operators off the factory floor seems possible and allows sourcing at locations where they are available. This also introduces the possibility of sourcing remote operators who are normally not interested or resourceful in a meat plant operation.

Reducing WHS issues of dangerous operations

The telemanipulation technology can make it possible to replace the operator's position with a robot. The operator can perform the dangerous task from a separated location in a secure working environment.

It will also be possible to improve the working environment by splitting tasks between multiple remote operators, rather than using local resources at repetitive tasks for long hours.

Combine robot path with operator skill

The telemanipulator setup can be utilized to its fullest by combining the skills of an operator with the precision and fast routine movements of a robot. Then it will be possible to deliver fast with less resources on automating complex/hard tasks that usually take a very long time to automate. Performing developments in such an environment could increase capacity and reduce working environment issues for complex operations.

Useful resources

Insert links to relevant online materials.

<https://www.universal-robots.com/products/ur10-robot/>

<https://www.haption.com/fr/products-fr/virtuose-6d-fr.html>

<https://polhemus.com/viper/>