Snapshot Report

AMPC
AUSTRALIAN MEAT PROCESSOR CORPORATION

Remote Operations – Shadow Robots

Remote Operations – Shadow Robots (Stage 2, Part B)

Project Code	Prepared by	Date Submitted
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Project Description

This project is a proof-of-concept example of robots being used to replace personnel in bandsaw meat cutting, where the robot is controlled by a remote operator. The work has been undertaken in response to a call from AMPC for a staged programme of development work on Remote Operations - Shadow Robots. This report covers Stage 2, Part B, where the general goal of Stage 2 was to improve the Proof-of-Concept shadow robot, developed in Stage 1, for selected aspects of useability and robustness.

Project Content

The shadow robot system integrated a Kuka industrial robot with a bandsaw using a bespoke vision-tracking and control system. The approach to development was through rapid-prototyping; get it working quickly, use, refine, improve then finalise. Initial testing was basic, cutting chops.

In the current work, the system was advanced to improve the shadow robot system robustness and useability by:

- Developing and demonstrating a 3D cutting mode (e.g. cutting down the spines of a saddle, removing the chump or similar).
- Creating a basic implementation of clearing the bandsaw table of cut meat to direct it for packaging.
- Complete designs for integrated meat in-feed and out-feed.
- Conduct preliminary work on using the bandsaw in combination with knife work (e.g. breaking/cutting/fat trimming).

Figure 1 shows a photograph of the shadow robot system (in a trimming configuration) being used by an operator at the 2022 AMPC Innovation Showcase. The position of the robot is controlled by an operator who is situated at an operator's workspace out of reach of the robot. The operator moves a tracked object within the operator's workspace. The robot end-effector "shadows" the motion of the tracked object in real-time such that the operator can manipulate the meat to be cut by the bandsaw.

Figure 1: Shadow robot system in trimming configuration being operated at the 2022 AMPC Innovation Showcase.

Project Outcome

3D-control of the robot was implemented using fiducial markers. The system has been successfully demonstrated with full 3D motion capability. The responsiveness was excellent (without lag) and the accuracy around sub-millimetre. We tested the system by making more complex cuts e.g. splitting a lamb saddle and cutting the chine bone. The success of this chine cut testing has shown that the shadow robot system, with minimal configuration changes, has the adaptability to be used for different tasks that require 3D motions. The fiducial marker tracking system, the single marker was extended to multiple-markers or “board” fiducial tracking. This increased the reliability and accuracy of the tracking. Notably tracking using fiducial markers presents the opportunity to have specific task-based markers.

Using the system with 3D-control allows more complex angular cuts to be made (e.g. chine bone removal on a beef striploin). Figure 2 shows a photograph of the system being used to perform a chine bone cutting action. In using the system with 3D-control to make more complex cuts it was noted that useability was often improved by locking-out or defining some settings. By example, an operator could reference the tracked object against a table whilst have the robot cutting with a vertical offset in the throat of the bandsaw. It also eliminated the system being over responsive for the prescribed task.

Figure 2: Photograph showing demonstration of remote chine bone cutting.

In addition to a configuration where the operator-controlled meat to be cut, a second configuration was developed and proven. This was a trimming application where the operator controlled a tool, in this case an electric kebab trimmer. The kebab trimmer was mounted to the robot, and the system was used to trim the fat layer off fresh beef brisket meat samples. In trimming, the system performed with comparable speed and precision as it did during the bandsaw cutting tasks. These two configurations show the versatility of a shadow robot system: control the meat or control the tool.

The shadow robot was demonstrated in a trimming-configuration at the AMPC Innovation Showcase in Melbourne, Victoria in October 2022 (see Figure 1). The system proved itself to be robust with many attendees having a go at using it. The ease by which a system might be installed in a processing facility was also evident at this event - the equipment was up and running in a day using a borrowed robot. This bodes well for potential retrofits in plants.

Benefit for Industry

The prototype shadow robot platform shows great promise as a multipurpose processing station for improving the safety and performance of tasks in meat processing. In the future, this shadow-robot platform can be tailored for specific meat processing tasks. Shadow robots are a great option for capturing the experience and knowledge of a skilled worker, making their job less dangerous and less tiring by having machinery do the hard work. The operator can also work remotely from a control room, either on-site or potentially off-site. Furthermore, in considering some of the repetitive tasks in the boning room, there is opportunity to add machine learning to the shadow robot system and in so doing, shadow-robots could be used on a development path to full-automation, removing staff from tasks completely.

The benefits of this shadow robot platform include:

- Relative simplicity in design (e.g. integrates off-the-shelf industrial equipment),
- Adaptable, responsive, small footprint, precise and operates in real-time,
- Removing staff from dangerous operations, via Hands-Off processing, and
- Improving Safety and Wellbeing, via reducing the high-risk nature of processing operations.

The addition of selectable operating modes:

- increases the useability and permits the speed of the robot to be utilised, and
- allows personnel skill and experience to be used in cutting with the shadow-robot.
- intermediate step on the path towards fully automated processing