Snapshot Report

AUSTRALIAN MEAT PROCESSOR CORPORATION

Beef striploin fat removal - Stage 2A)

Twin-head laser and ultrasonic 3D fat-lean boundary profiling sub-system

Project Code	Prepared by	Date Submitted
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Project Description

Trimming to achieve a specific fat thickness on a beef striploin primal is a highly manual process requiring significant human skill and judgement. The sensory processes that allow determination of the fat thickness and the positioning of the striploin in the geometric space relative to a work datum are essential to automation developments. With the use of ultrasonic measurements in a manner that determines profile data in the robot frame of reference, the process of cutting automation may be realised without the need for laborious referencing (Figure 1). It is important to state, that once the capability is reached, the level of control to archive target fat cover specification on a beef striploin will be beyond what is achievable manually as human sensors could not have the possibility to gauge fat thickness, except in a notional manner by feeling the top of the fat over the profile of the striploin. Moreover, the control over the trimming process removing fat is limited to the accuracies that may be achieved by the manual manipulation of a knife or a cutting tool being driven through the fat along the path that removes variable fat thickness to leave a known specific thickness of fat behind on the lean meat.

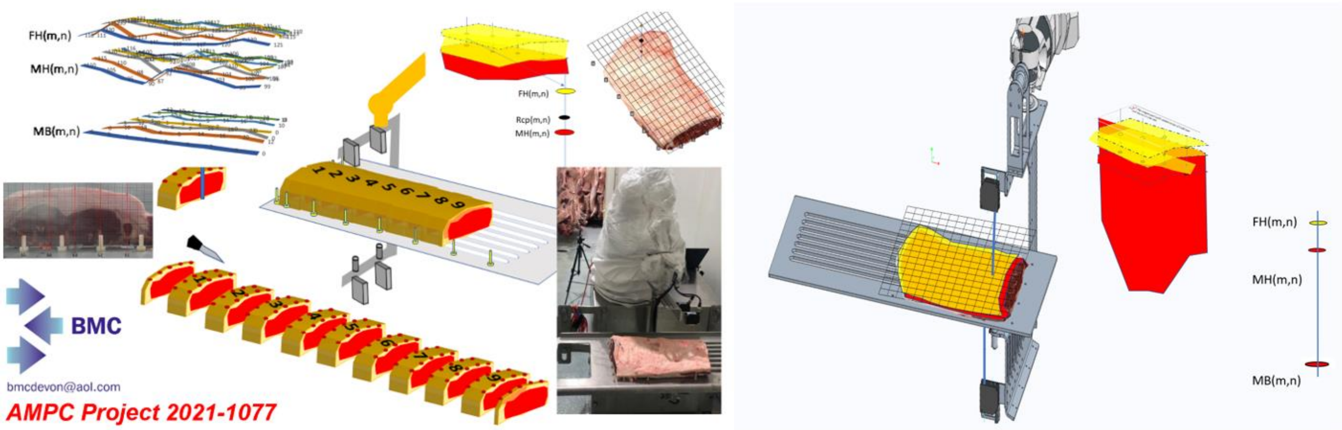

Figure 1: Robotic profile measurement of meat and fat heights in a robot workspace.

Project Outcome

Figure 2 presents the physical set ups for the single, twin, and more (up to 7), sensor arrangements respectively.

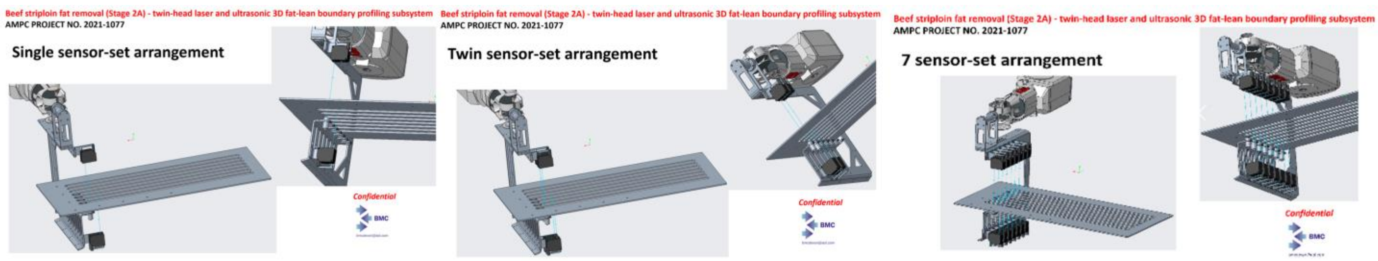

Figure 2: Single, Twin and 7 sensor arrangements.

Figure 3 presents the modular arrangements for the instrumentation, which is for acquisition of the measurements, transfer ready format for use in the robot programs guiding the trimming paths and the interfacing for presentation of the fat-meat profile within the striploin (see Figure 4 bottom right).

The integration of the sensors with a robot programme providing a structured sequence at specific measurement nodes provides for the determination of meat and fat heights above the reference plate on which the beef striploin sits (see Figure 4).

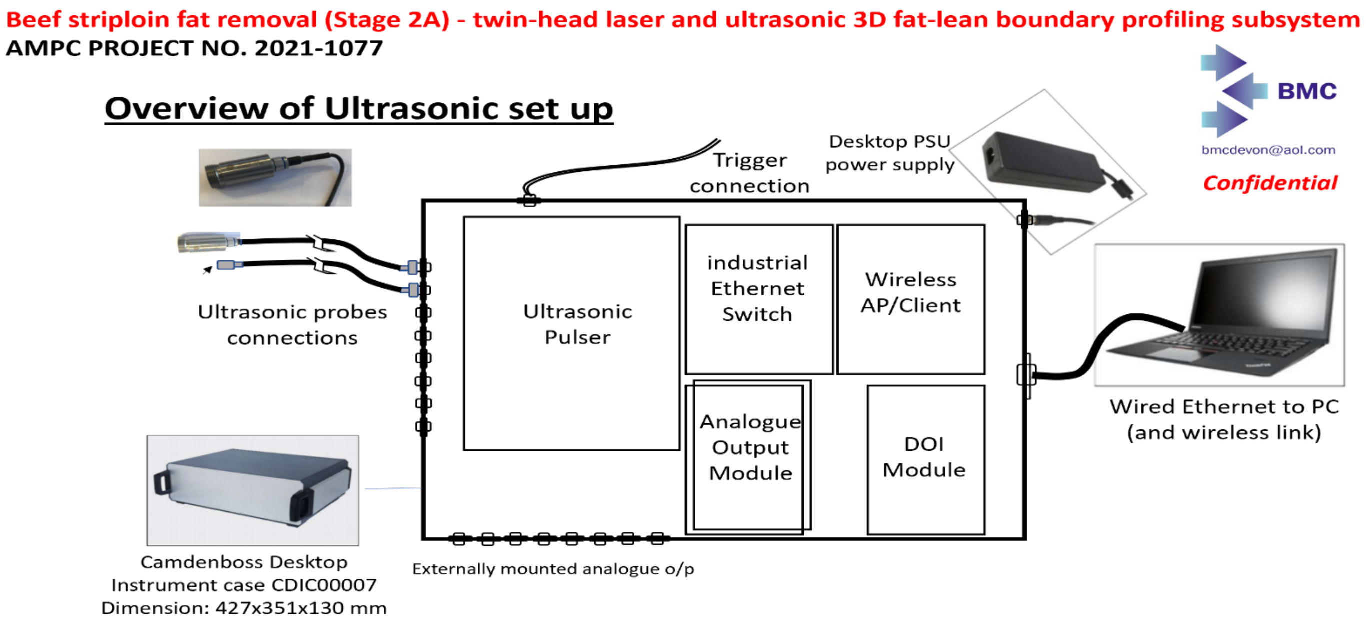

Figure 3: Multi-head ultrasonic and laser sensor arrangements.

Figure 4 shows schematics of the set up and the planned process for measuring the striploin profile.

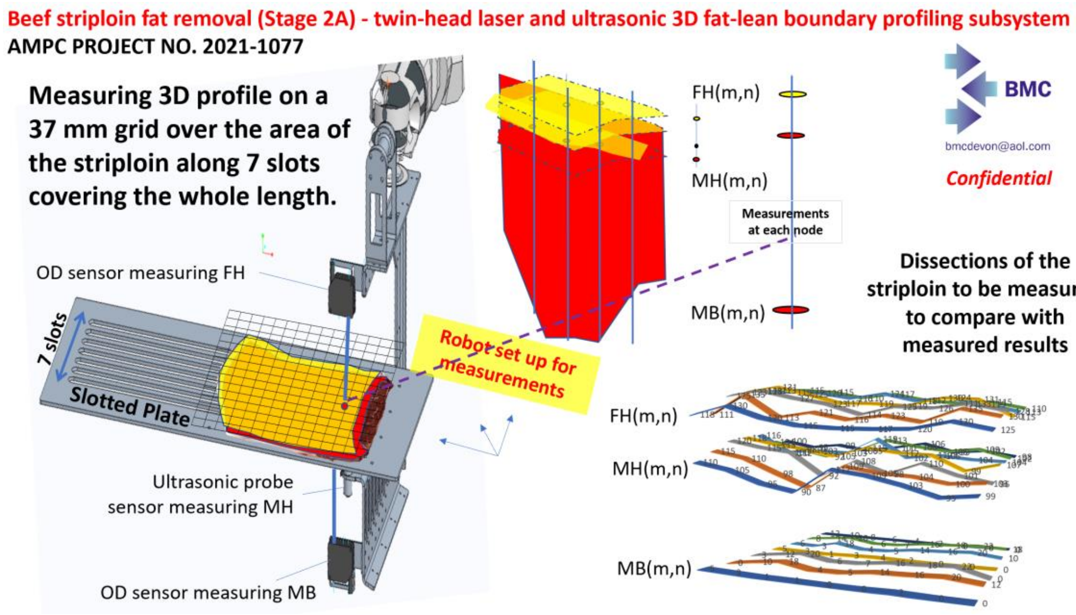

Figure 4: 3D striploin profile measurement.

Robot programming has provided for the sensor positioning at each node, measuring:

- fat height (FH) above the slotted plate,
- meat height (MH),
- meat base (MB) relative to the top surface of the slotted plate.

The measurements, digitally stored within the robot controller may be referenced for trimming; however, for the purposes of validation, the data is transferred using an ethernet link to an external computer to access the measurements data file in raw format, which in turn are manually transferred to an excel spreadsheet.

Striploin beef primal pieces have been measured and each striploin has been sliced into strips that allow direct manual measurements of the same measurements taken by the robot, but using a ruler.

20 tests have been conducted using striploin pieces in 2 separate trials using the OD sensors and Ultrasonic probes integrated within a robotic cell. Each robot measurement run has been followed by dissection of the same Striploin primal. The 20 specific tests have compared manual and robotic measurements at specific nodes to quantify the difference and the measurements of FH (fat height) and MH (meat height) as each node, which is essentially intended for the determination of Rcp (the robot cutter tip heigh), which is the point the separation tool would need to pass for the gap between Rcp and MH to be the thickness of the fat to be left behind at that node (Figure 5).

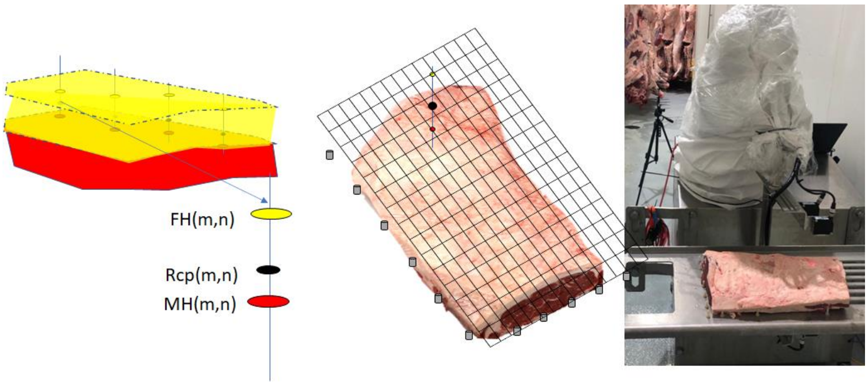

Figure 5: Robotic set up for measurements.

The measurements by the robot provide FH and MH (meat height and fat height) relative to plate with slots that allow access for the ultrasonic probe to make contact with the underside of the striploin piece.

Figure 6 illustrate the approach to slicing each striploin primal piece.

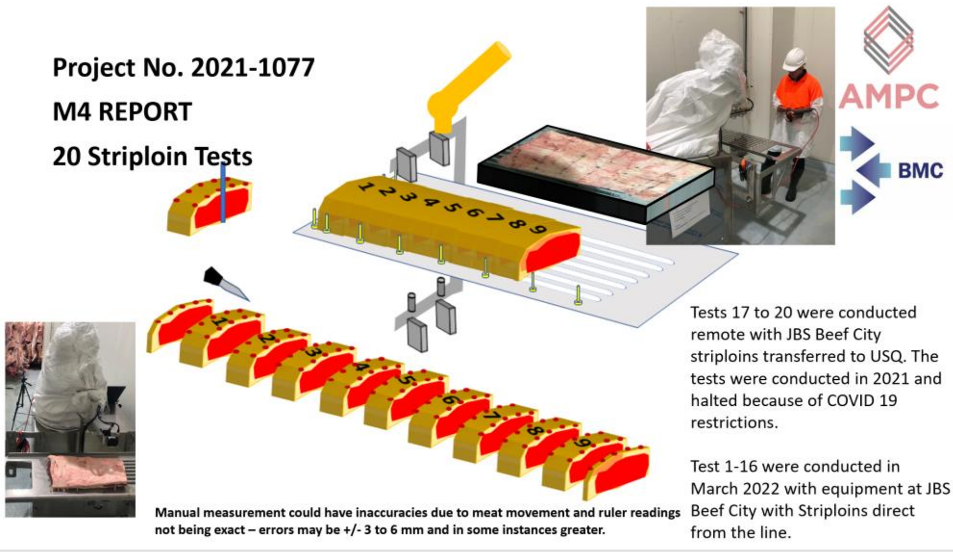

Figure 6: Slicing for manual measurements.

A ruler has been used to measure MH and FH at the sliced face of the striploin with the dot markings on the top of the fat giving the approximate node positions of the robot measurement points (identified and physically marked using a food grade marker pen) during the robot cycle (Figure 6).

In summary, for the nodes at which valid measurements were taken, 62% of the meat height (MH) measurements were within 2 mm of the same taken manually after dissection for each node, 29% within 4 mm, and 9% outside this rage. The figures for FH (fat height) were 69% within 2 mm, 22% within 4 mm and the remaining 9% outside this band. See Table 1.

It should be noted that the errors due to manual measurement impact the findings. On the whole, the results are considered accurate and consistent when using the robotic 3D profiling process, especially with the variability in surface profile of the fat and presence of intermuscular fat. Contact between the ultrasonic probe and the meat is also impacted by the shape and the inconsistency of the meat surface of the striploin underside.

With all considerations it is reasonable to conclude that the measurement system would provide the necessary number of data points to the expected accuracy for the profiling of the fat lean interface to be mapped for the calculation of Rcp, the points though which a cutter tool path can be fitted for guiding a robot for fat trimming.

AMPC PROJECT No. 2021-1077									
M4 - Robot sensor measurements and Manual measurements comparison									
		MH	Ultrasonic - Meat thickness			FH	OD sensor Fat height		
No		Valid nodes	Within 2mm	Within 4mm	Outside 4mm	Valid nodes	Within 2mm	Within 4mm	Outside 4mm
1	Striploin 1 - JBS	17	10	5	2	31	29	2	0
2	Striploin 2 - JBS	20	13	6	1	36	28	8	0
3	Striploin 3 -JBS	9	8	1	0	32	22	5	5
4	Striploin 4 -JBS	10	7	3	0	32	26	5	1
5	Striploin 5 - JBS	11	9	1	1	28	14	8	6
6	Striploin 6 - JBS	5	3	2	0	28	11	5	12
7	Striploin 7 - JBS	13	8	5	0	36	24	10	2
8	Striploin 8 - JBS	21	14	6	1	36	22	12	2
9	Striploin 9 - JBS	15	9	3	3	26	14	8	4
10	Striploin 10 - JBS	13	10	3	0	25	17	4	4
11	Striploin 11 - JBS	12	8	3	1	32	24	7	1
12	Striploin 12 - JBS	9	5	1	3	30	15	8	7
13	Striploin 13 - JBS	9	8	1	0	32	22	9	1
14	Striploin 14 - JBS	12	5	7	0	28	17	10	1
15	Striploin 15 - JBS	15	5	8	2	36	20	12	4
16	Striploin 16 - JBS	21	14	6	1	32	27	5	0
17	Test 17 SLP 01	17	8	5	4	2	1	1	0
18	Test 18 SLP 02	11	6	4	1	19	18	1	0
19	Test 19 SLP 03	18	10	5	3	19	15	2	2
20	Test 20 SLP 04	36	22	11	3	39	36	3	0
	Total	294	182	86	26	579	402	125	52
			62%	29%	9%		69%	22%	9%

Table 1: comparing robotic measurements and manual readings for MH and FH

There is a shortfall in respect of reaching 85% of the measurements being with 2 mm: the figures calculated being 62% within 2 mm for meat height (ultrasonic) measurements at each node, and 69% within 2 mm for OD laser sensor measuring fat height at the same point of the striploin. The contributory factors to the errors are attributable to manual measurements being at error by +/- 5 mm when using a ruler, whilst there is also significant shape and profile variation in the striploin, contributing to the process of measurement. These are causes by the preceding processing stages such as de-boning or de-hiding leaving the fat cover broken or the meat surfaces not fully trimmed.

Benefit for Industry

The automation to be reached will avoid over trimming, efficiencies and improvements in work conditions.