OPPORTUNITIES AND CHALLENGES IN FOOD AUTOMATION – SHAPING THE FUTURE

Koorosh Khodabandehloo

Business and Manufacturing Consultancy, Culmstock Technology Centre, Culmstock, Devon, EX15 3LA, United Kingdom

Adjunct Professor, University of Southern Queensland, National Centre for Engineering in Agriculture, P9, West St, Toowoomba, QLD 4350 Australia

Email: bmcdevon@aol.com

I. INTRODUCTION

The past 30 years has seen important developments in robotics for the food sector. These have included primal cutting, de-boning and general handling including packaging and end-of line operations such as palletising. In 1980s and 1990s several international R&D projects were concerned with deboning[1,2], primal cutting of meat carcasses[3], packaging[4] and general handling of non-uniform products[5]. Several solutions are now commercial; however, the number of installations to date have not been as anticipated, especially in the high care or main processing areas of food plants. The manual tasks in the handling of 'raw or naked' food require skills and capability to sense, decide course of action in handling as well as execution of tasks such as cutting or controlled placement of the product. A distinction exists between intelligence and skill in the context of robotics[6]. The challenge of performing skilled tasks involves dexterity in handling tools as well as products with non-uniformity. Understanding the behaviour of food for automatic processing is fundamental to reaching future automation solutions. Many academics and industrialist continue in this venture to generate new solutions[7], with the widespread use of robot technology remaining a target for the future. This paper presents, with the aid of an examples, the challenges to shaping a new future for robotics for food production

II. ROBOTIC TRIMMING

Among the many challenges facing robots to handle or process food is the task of trimming. Meat, vegetables and many food products are trimmed for presentation or to meet final product specification. Trimming fat from a whole striploin primal to achieve better presentation of the meat after slicing is such an example, requiring skill and judgement. Manual fat trimming is a labour intensive and highly inaccurate process, especially when a uniform layer of fat is to be left on the lean striploin beef.

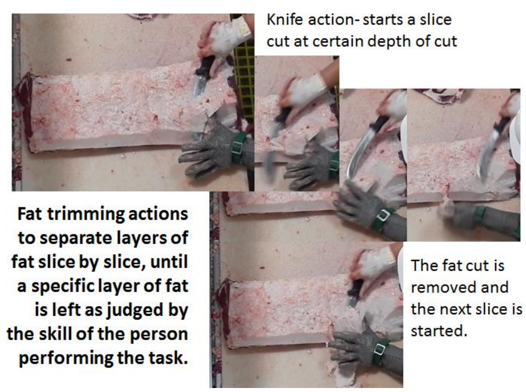


Figure 1. Manual fat trimming

The precise location of the fat-lean boundary cannot be visually observed by an operator. There is, thus, significant skill involved in both handling and visual as well as touch sensing as illustrated by Figure 1. The manipulation and guidance of the knife requires judgement with the ability to start, guide and move the knife applying the correct degree of force to instigate separation through the fat at the correct depth; removing layers that leave the desired fat surface shape and thickness over lean meat. A highly adaptable, controlled trimming solution is needed, using sensing capabilities that achieve the same or better results, compared to an experienced manual trimmer.

III. RESULTS AND DISCUSSION

A basic requirement in reaching a robotic solution is the characterisation of the range of variability in product size and form. In the case of fat trimming, Figure 2 shows the results of a study performed on fat cover depth over striploin primal cuts, prior to specifying the solution as a most important step in the project. Fat cover on a beef striploin primal may be up to 75 mm in thickness. Fat thickness over the area of a striploin may change significantly.

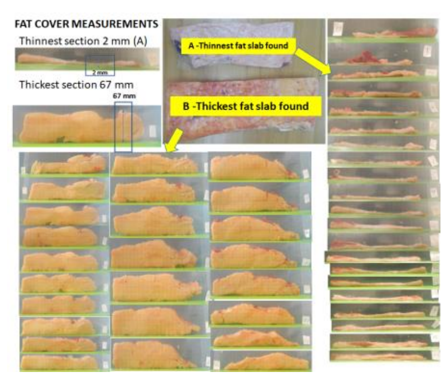
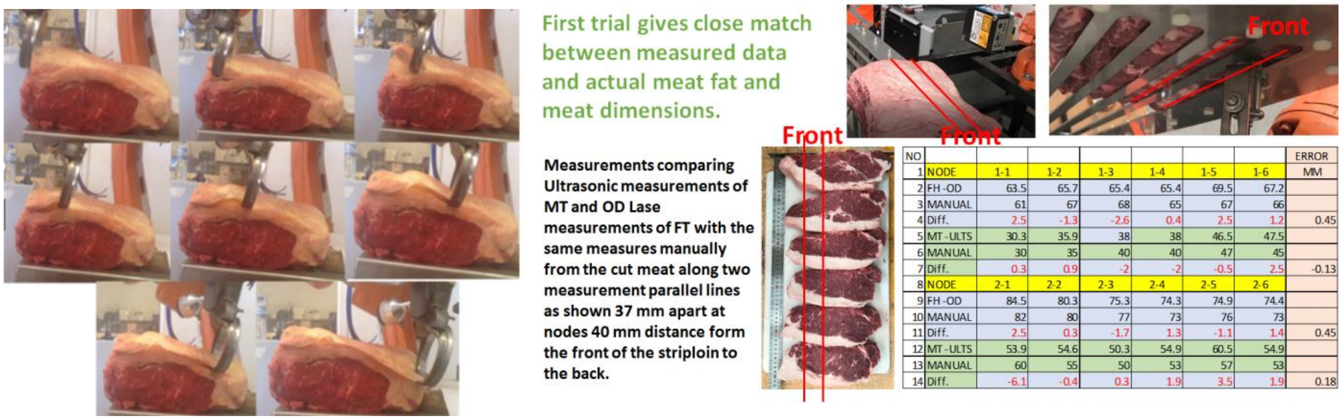


Figure 2. Fat cover on beef striploin

A 50 mm change in height over a 25 mm distance both along the length or the width on a striploin primal may be encountered during trimming.

Use of ultrasonic and a laser profile measuring device to guide a robot with a trimming provides a practical approach to reaching a first robotic solution, which has been implemented.

Figure 3 shows images of trials, following a specified line of cutting using sensory inputs. A powered rotary tool used by a robot follows through the striploin fat. The specification of the process and implementation of a robotic fat trimming system has been possible only after quantification the striploin and fat cover variability.



NO								ERROR
1	NODE	1-1	1-2	1-3	1-4	1-5	1-6	MM
2	FH -OD	63.5	65.7	65.4	65.4	69.5	67.2	
3	MANUAL	61	67	68	65	67	66	
4	Diff.	2.5	-1.3	-2.6	0.4	2.5	1.2	0.45
5	MT - ULTS	30.3	35.9	38	38	46.5	47.5	
6	MANUAL	30	35	40	40	47	45	
7	Diff.	0.3	0.9	-2	-2	-0.5	2.5	-0.13
8	NODE	2-1	2-2	2-3	2-4	2-5	2-6	
9	FH -OD	84.5	80.3	75.3	74.3	74.9	74.4	
10	MANUAL	82	80	77	73	76	73	
11	Diff.	2.5	0.3	-1.7	1.3	-1.1	1.4	0.45
12	MT - ULTS	53.9	54.6	50.3	54.9	60.5	54.9	
13	MANUAL	60	55	50	53	57	53	
14	Diff.	-6.1	-0.4	0.3	1.9	3.5	1.9	0.18

Figure 3. Robotic fat trimming in development trials

Reaching automation solutions requires quantification such characteristics with respect to the handling and cutting processes. Testing in an industrial environment, processing significant number of pieces, to validate the results of laboratory tests is the only way new robotic systems can reach commercialisation.

IV. CONCLUSION

The challenges in developing new robotics for the food sector remain, as illustrated in the example of fat trimming. Processing meat, preparing ingredients from vegetables to slices of cooked products, and assembly in ready meals remain challenges for robotics. Researchers in food science and engineers specialising in mechatronics, robotics, artificial intelligence need to work closely to integrate cost effective solutions transferring results from laboratories to factories. Decades of work remain for industry to have the options to use industrially robust robots to produce quality food at lower prices for the consumers.

ACKNOWLEDGEMENTS

The author wishes to express sincere appreciation to all colleagues and researches that have provided so much inspiration and input to the many food robotics projects, kindly funding by industry and institutions including the European Commission, Meat and Livestock Australia, Australian Meat Processors Corporation and UK Research Councils.

REFERENCES

1. Khodabandehloo, K. (1989). Sensory Guided Robots for Cutting and Handling of Meat Products, 35th International Congress on Meat Science and Technology, Denmark, (pp165-172).
2. Maddock, N., Purnell, G., Khodabandehloo, K., (1990). Robot Deboning of Beef Forequarters, Robotica, Special Issue, Vol 8, (pp303-310).
3. Wadie, I.C., Khodabandehloo, K., (1995). Path Generation for Robotic Cutting of Carcasses, International Journal of Computers and Electronics in Agriculture, Vol. 12, (pp65-80).
4. Khodabandehloo, K., (1990). Robotic Handling and Packaging of Poultry Products, Robotica Special Issue, Vol 8, (pp285-297).
5. Brett, P. N., Shacklock, A. P., Khodabandehloo, K. (1991). Research Towards Generalised Robotic Systems for Handling Non-Rigid Products, 5th International Conference on Advanced Robotics, Vol 1 IEEE Cat No. 91TH0376-4.
6. Rennell, I. J., Khodabandehloo. K., (1989). Development of Skilled Robots: A New Approach in Robotics, 20th International Symposium on Industrial Robots, Japan, (pp145-153).
7. International Food Automation Networking Conference. (2018): http://ifan.gtri.gatech.edu/2018-conference-agendaprogramme