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Automated Sheep Counting for the Live Export Industry

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Executive summary

Australia exported 1.1 million live sheep in 2019, of which 96% left from Fremantle port. Currently, all sheep are manually counted several times at the port and the quarantine area prior to export. Counting at the port is conducted by tally clerks from both Australia and abroad. There are a few motivations to develop automatic sheep counting technology however most important is the discrepancy in counts between both sides of the transaction.

For the technology to be appropriate for the Australian livestock export industry, three criteria appear to be essential: accuracy, counting speed and cost. Currently, the best human counting accuracy is around 95-97%, but tally clerks must contend with long hours and high volumes of sheep; for instance, at Fremantle Port, WA, the counting operation may take 12-24 hours. Therefore, a goal of 99.5% accuracy for the proof-of-concept project was set. The counting speed should be real-time so that the number of counted sheep can be reported to the export company immediately after loading. The designed system should also be cost-effective in order to reduce count discrepancies and labour costs that derive from manual counting.

During the project, after a few design iterations and field tests, the team developed a hardware platform that covered two sheep loading races. Two normal video cameras were attached to the platform to monitor sheep transition in real time. A live video stream was then transmitted through Ethernet cable to a desktop/laptop so that sheep were counted with the software. The number of sheep is shown on the screen in real time and the new system will also allow for further auditing as the video footage is saved locally.

The underlying counting technology involved monitoring and assigning each sheep with a unique ID using artificial intelligence (AI). Each sheep was monitored from when it entered the pre-defined counting area displayed on the computer screen until it left the counting area. Inside the counting area, there was one counting line which the AI model used to check sheep walking direction. A sheep crossed the counting line by moving from the “entrance” to the “exit”. However, if a sheep crossed the counting line but then walked back to the truck after recrossing the counting line, the system would record two counts – “counting-in” and “counting-out” – which the system recorded as a zero count.

For model training and testing, the UTS team travelled to Fremantle Port five times for video data collection and trials, ensuring that the AI model was tested under real-world conditions. The tests demonstrate that the sheep counting technology has a 99.9% accuracy rate. This is higher than the initial goal of 99.5% and even higher than the manual count accuracy of 95-97%. The system ran in real-time and achieved 50 frames-per-second when a high-speed camera (>30 frames/sec) was used. The system was also tested in two saleyards for sheep unloading with 100% counting accuracy.

Many saleyard managers have shown great interest in commercialising the technology for sheep counting, and several demonstrations have been organised at saleyards. The developed system can significantly reduce human labour and minimise disputes or irregularities in livestock trading. The outcomes of this project could also be used in quality assurance systems.

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1 Background

Accurate animal counting is a very important task for the livestock industry all over the world. Australia exports around 1 million sheep per year, primarily to the Middle East, on vessels that carry around 40,000 – 50,000 head per voyage. As sheep are not individually identified and traceable, they are counted by multiple staff onto each vessel. Sheep are often loaded onto races / ramps that are several animals wide, which is challenging to accurately count. Observing sheep passing through a race can be a very tedious, physical and psychological demanding activity, especially over long periods of time.

This project focuses on developing an automated, video-based system for counting sheep as they are loaded on and off live export vessels. Currently there is no sheep counting system on the market. The closest related research is traffic counting (e.g. vehicle, pedestrian). However, unlike rigid vehicle or up-right pedestrians, the shape of sheep bodies can vary greatly, especially under extreme congestion. This situation will significantly impact on sheep counting and result in difficulty to achieve high counting accuracy, as mentioned in MLA report LIVE.106 Automatic Counting of Sheep. Through this project, a proof-of-concept prototype software platform has been developed to perform the analysis of sheep counting. It can significantly reduce labour requirements and minimise disputes over irregularities in counts in livestock trading. The outcomes of this project could also be used in quality assurance systems.

2 Project objectives

In accordance with the UTS/MLA research agreement, the project objectives are to:

1. develop a video camera-based algorithm system that demonstrates a level of at least 99.5% accuracy for counting sheep embarking a live export vessel
2. complete a live demonstration with reasonable software function and hardware system setup satisfying the requirement of counting sheep onto a vessel
3. produce technical reports detailing software design scheme and the relevant camera setup scheme

3 Methodology

3.1 Overview

Considering current sheep loading infrastructure, cameras were set up in appropriate locations and angles to monitor sheep transfer, e.g. from truck to vessel. The sheep counting model was trained offline with an artificial intelligence (AI) based machine vision and learning model.

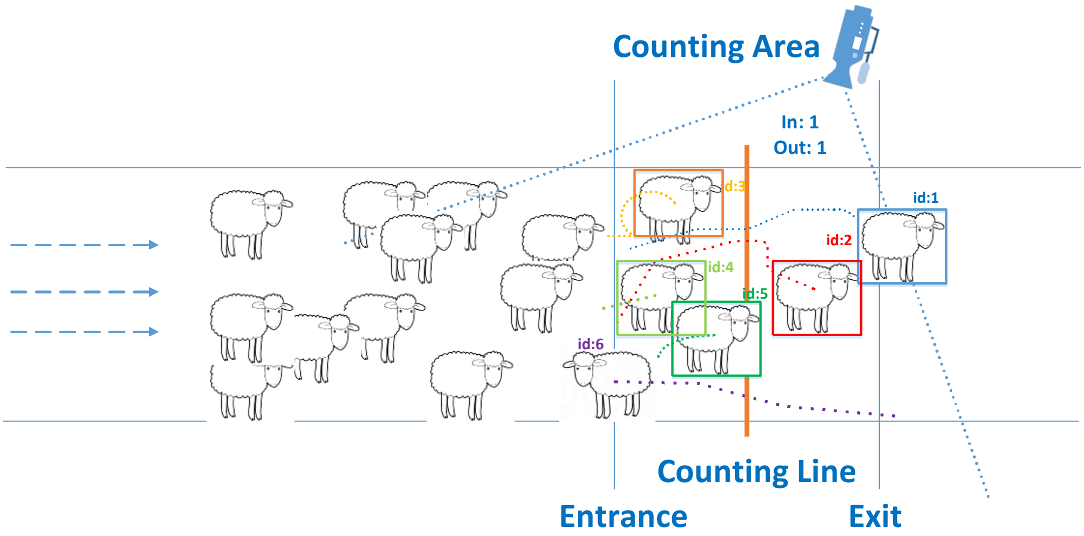

Fig. 1: Counting each sheep in the counting area.

The following definitions describe the system, referring the Fig.1:

1) **The Counting Area**: the camera will cover the width of the sheep race. Within the race, a region is manually designated as the "sheep counting area" between the lines of the Entrance and Exit.
2) **The Entrance**: by following sheep traffic direction from truck to vessel, the Entrance should be the first location that the sheep enters the Counting Area.
3) **The Exit**: exit should be the last location that the sheep leaves the Counting Area if following sheep traffic direction.
4) **The Counting Line:** this is normally set in the middle, between the Entrance and the Exit. Any sheep walking from truck to vessel must cross the Counting Line.
5) **Counting-In/Counting-Out:** If the sheep move from the Entrance to the Exit, and cross the Counting Line, this is known as "counting-in". However, if the sheep travels against the direction (from the Exit to the Entrance), and walks back across the Counting Line, this is then known as "counting-out".
6) **The Sheep Trajectory:** with a unique ID, the Sheep Trajectory is the path of movement of the sheep in the Counting Area for the whole time period, illustrated by the dotted line.

Sheep are assigned a unique ID from the moment they enter the Counting Area until they leave. The consecutive location over the video frames will form a walking trajectory that is used for counting. In the sheep unloading area, sheep normally move from the Entrance to the Exit. That is, sheep cross the Counting Line and finally leave the Counting Area and thus should be counted as "counting-in" (e.g. sheep id: 1 in Fig. 1). It will be counted as "counting-out" if sheep move from the Exit to the Entrance (e.g. sheep id: 6 in Fig. 1). For other sheep ids 2, 3, 4, and 5 in Fig. 1, since they do not pass the Exit, none of them will be counted as "counting-in. For sheep id 3, 4 and 5, they even have not crossed the counting Line yet.

3.2 Infrastructure settings

Based on sheep loading infrastructure at Fremantle Port, a top view mounted camera was adopted to monitor one race as illustrated in Fig. 2. and a hardware platform for data collection is shown in Fig. 3. The height of the platform is adjustable (around 5m) compared to the height of the race 1.5 m. This enables the camera (3.5m high over the race) to cover enough space for deploying a video-based algorithm for sheep counting. This platform can support two races with multiple cameras shown in

Fig. 3. The AXIS M1145-L Network Camera was selected for video capturing in this project due to its stability on video quality during both day and night under the actual lighting conditions at Fremantle Port. The power for the camera is supplied through an Ethernet cable (Power over Ethernet, PoE). The resolution of the image in video sequences is 800 × 600 pixels. The video sequences are transmitted through the Ethernet cable to the computation backend. Currently, a laptop equipped with a Nvidia GTX 2080 GPU card handles the streamed videos. In addition, the video data can be saved locally using an SD card inside the camera.

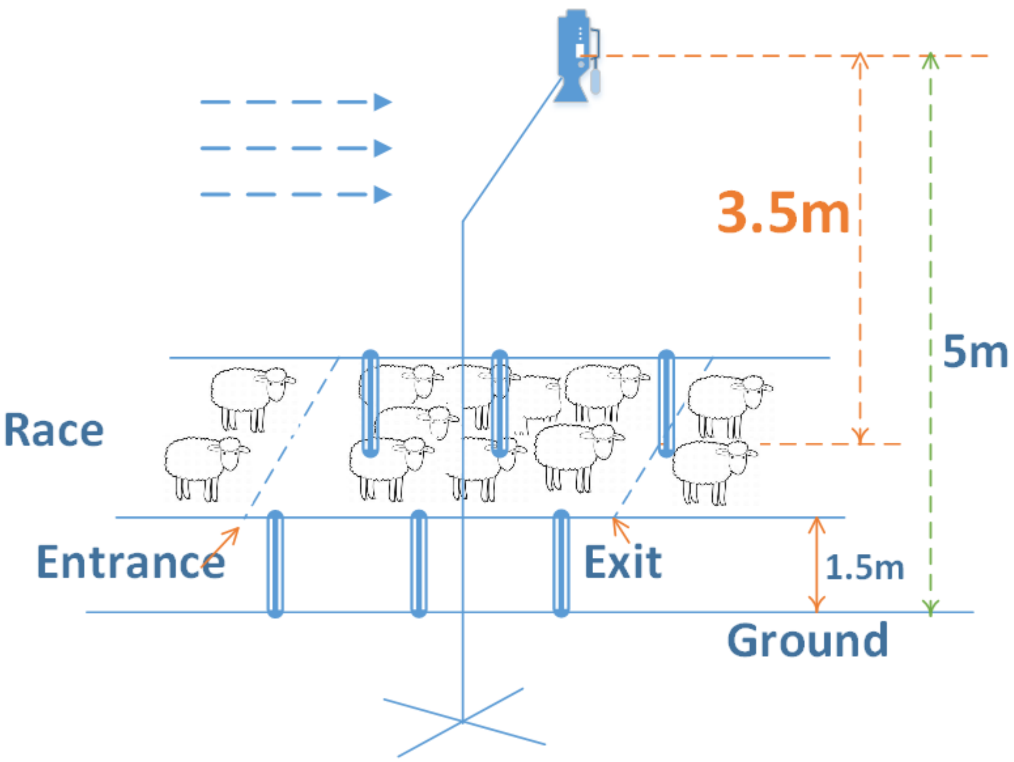

Fig. 2. The camera setting for sheep counting.

Fig. 3. Illustration of hardware design including two cameras covering two races.

4 Results

The algorithm running speed for sheep counting was shown to reach 50 frames per second. The system has been tested to support sheep counting in two races simultaneously with a speed of 40 frames per second (fps). The algorithm running speed is even ahead of the video camera capturing (30 fps) in real-time.

The counting system has been tested on the video data collected at Fremantle Port. In total more than 18,000 sheep on the video have been manually counted to check the counting accuracy of the system, which reached 99.9% and above. It should be noted that workers and dogs occasionally entered the counting area in the recorded video footage.

The counting system has been also tested in saleyards 1) CTLX (Central Tablelands Livestock Exchange) located in Carcoar NSW 2791 and, 2) SELX (South Eastern Livestock Exchange) located in Yass NSW 2582. In total, the system was operated for around 6 hours. The truck drivers and saleyard dogs regularly entered the video counting area in order to keep sheep flowing through the race. Nevertheless, the system correctly identified these incursions and excluded them from counting. The final results were perfect classification (100% accuracy).

5 Conclusions/recommendations

A comprehensive survey and literature research did not identify commercial or operating automated sheep counting systems or technology adapted for use in the animal industry. There are a few cattle counting technologies that use drones. However, most of these technologies for counting animals focus on examination of static images rather than exploring the temporal information over real-time videos. This is different from the use case for this project.

From this project, a prototype system has been developed to achieve real-time sheep counting for the live export industry. Through comprehensive testing, a counting accuracy of 99.9% was attained. This is more than the project accuracy goal of 99.5%. Real-time trials in saleyards also demonstrated an accuracy of 100% and showed the robustness of the system.

6 Appendix

6.1 Acknowledgments

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