final report

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Augmented reality for automation machine maintenance management

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Abstract

P.PSH.0908 demonstrated the use of Virtual Reality (VR) and Augmented Reality (AR) systems within the meat processing sector, with a key focus on communication for machinery sale, and on technical support in maintenance. This will enable more informed buying decisions and better room layouts, as well as providing greater machine information to the maintenance engineer's fingertips.

An initial AR application was developed by the University of Otago, demonstrating maintenance support on the Bladestop. This was then a model for Scott to develop a more detailed package for use with Leap lamb boning automation. Sales applications came from Visual Components animated simulation and 360 video filming.

These applications clearly demonstrated how VR and AR can improve visualisation of 3D concepts, making buying decisions easier and giving comprehensive information to maintenance engineers.

Executive summary

Decisions on purchasing of equipment are often compromised by the difficulty of trying to communicate engineering concepts to non-engineering customers in a way that is able to be easily visualised. Effective communication is also important for machine maintenance. Getting support from technical experts such as machine suppliers currently relies on phone, e-mail and sometimes video conferencing. When this is not enough, it is often necessary to have the technical experts make a service visit, which can be costly and can cause delays to production.

It can be difficult to secure and maintain adequate engineering expertise on-plant, which is made more difficult by the complexity of machinery now being introduced. It is anticipated that having an engaging way of supporting site engineering staff that reduces their need to be experts in each machine would broaden the pool of potential candidates.

The project described here sought to address these issues using virtual reality (VR) and augmented reality (AR) headsets through the following objectives:

1. Develop a demonstration 3D training and maintenance manual for Bladestop and for the X-Ray, Primal, Middle and Forequarter System, including a remote support facility.

2. Demonstrate the technology to the Australian meat industry at a production site employing Scott equipment.

3. Develop an augmented reality immersion into horizontal and vertical 3D beef boning concepts developed.

4. Develop an augmented reality “flythrough” of LEAP system at Brooklyn. Once completed to be presented to the MLA/MDC Board.

An application was developed for the Bladestop saw by the University of Otago, for use on a Microsoft Hololens AR headset. This demonstrated the ability to view 3D holographic models of internal machine components from the outside of the machine, and to turn model components on and off. The application also demonstrated a remote link to a service-desk technician, who could see the scene that was being displayed in the Hololens, and could control the turning on and off of model views remotely as well as talking via the headset to the person wearing the Hololens.

A further application was developed by Scott demonstrating the ability to use a Hololens as a maintenance tool on the larger Leap systems (X-Ray, Primal, Middle, Forequarter processing). This was constructed on the backbone of the Brooklyn system Manual, and as well as the features of the Bladestop system it displayed virtual page navigation and model displaying from links on the Manual pages. The significance of this system is in its ability to handle larger machines (larger file size), and it has been written in a way that makes it easier to convert it for use for different machines.

The Brooklyn system has been demonstrated to selected individuals. It will be displayed to the wider industry in conjunction with a proposed industry open day at Brooklyn to demonstrate the Leap system.

The Solidworks 3D models used to demonstrate Scott’s beef boning automation concepts in P.PSH.091 were imported into the machine simulation package Visual Components, and machine moves were simulated in this. This was then exported to a file format able to be viewed in VR on a Windows Mixed Reality headset.

A 360 video was filmed of the Leap system in production at Brooklyn, and this was demonstrated to the Australian Meat industry at the MLA AGM and Red Meat Industry Forum at Alice Springs in November 2017.

The key insights from this project are:

- VR and AR technologies promote better visualisation of plant and machinery. Details are readily recognisable, and the headset wearer can walk around them and view them from all angles.
- The remote connection provided within the AR format is an effective way of bridging issues of remoteness for technical support.
- VR applications in particular are readily available for adoption.
- With an initial investment in application template development, AR applications can be rolled out reasonably easily with a medium level of skill.
- The machine manual is a useful starting point for developing an interactive AR machine application.

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1 Background

1.1 Reasons for undertaking the R&D

For all its equipment Scott provides very extensive maintenance manuals, and also ensures the key personnel at the facility are well trained in its operation and maintenance. More recently Scott has offered cadetships to selected customers whereby a staff member chosen by the customer undergoes a period of work experience and training at Scott facilities to familiarise themselves with the technology in a very hands-on manner supported by Scott technical personnel. A major flaw in all these aspects remains the high turnover of staff often seen at meat processing facilities. This project was aimed at developing a method of applying technical knowledge which is quick and easy and can be self-taught.

In addition, good clear communication is the key to sales & marketing activities. People in non-engineering industries often struggle to clearly visualise a proposed machine and its outputs. Another reason for this R&D is to provide a toolkit for efficient and clear visualisation of engineering products for purposes such as sales & marketing.

1.2 Significance for the Meat Industry

The level of equipment normally found in a processing plant is relatively unsophisticated. With most processes involving continuous or repeated action there is little need for complexity, and the job of a maintenance engineer involves a lot more *doing* than *diagnosing*. When faced with more complex equipment like Scott and others are introducing to the industry it is understandable that diagnostics would be quite daunting.

Meat processing plants are often in remote locations not easily serviced by centralised technical organisations. The remoteness also contributes to difficulty securing and retaining good engineering talent.

When a new machine is purchased, it is obvious for the machine supplier to provide full training to the customer. But inevitably staff turnover can result in the site having inexperienced people taking responsibility for machinery.

These issues can effectively be addressed through the use of augmented reality (AR) technology.

- A maintenance package on the AR can lead an engineer through the steps for maintenance and diagnostics.
- It is often possible to remote-link these devices also, in order for the site engineer to communicate directly with a centralised service technician who can see the same scene and can control the imagery displayed in the headset.
- Training can be in-built to an AR headset, or via remote link to allow real-world training at any location without the need to travel or for the trainer to travel. With in-built training, this can also happen at any convenient time.

Also daunting is the task of understanding how to lay out new equipment within an existing plant for best results. Normally this won't mean the difference between purchasing equipment or not, but it can significantly lengthen the time to make a decision, and in some cases errors of judgement can result in reduced benefits from the new equipment or compromise for existing equipment. Using Virtual Reality (VR) or AR to visualise layouts allows the prospective purchaser to very quickly visualise not only how a layout will look, but can also allow them to walk around it to fully understand how the layout will interact with all surroundings. Changes can be made and tested very quickly.

1.3 Overarching Aims of the Project

In this project we have to explored AR and VR technologies to determine how best to structure them for beneficial use in the meat processing industry. After researching hardware and software platforms we chose some fairly generic ones for our use and tested out VC from 3D filming and from 3D simulation, and we have developed an application for AR use for machine maintenance. These have had some limited industry viewing and we intend to expand their use in the industry.

2 Project objectives

2.1 Objective 1

Develop a demonstration 3D training and maintenance manual for Bladestop and for the X-Ray, Primal, Middle and Forequarter System, including a remote support facility.

2.2 Objective 2

Demonstrate the technology to the Australian meat industry at a production site employing Scott equipment.

2.3 Objective 3

Develop an augmented reality immersion into horizontal and vertical 3D beef boning concepts developed.

2.4 Objective 4

Develop an augmented reality “flythrough” of LEAP system at Brooklyn. Once completed to be presented to the MLA/MDC Board.

3 Methodology

3.1 Initial Investigation

An initial desktop investigation was conducted to understand the state of the AR/VR market and in particular the hardware providers for that market. This investigation led Scott to the adoption of Microsoft-based platforms – the Hololens for AR and Windows Mixed Reality for VR.

Fig. 1: A Hololens-wearer approached a mock-up Bladestop bandsaw.

Fig, 2: An Acer-branded Windows Mixed Reality VR headset and controllers.

3.2 Objective 1

After committing to the Hololens for AR development, the University of Otago was initially contracted to develop an example Hololens application for the Bladestop bandsaw. The application developed demonstrated:

- Referencing: The Hololens is able to identify a marker in a defined location (the marker used being a printed University of Otago logo). This provides a reference for positioning a skeletal 3D holographic model of the saw, which overlays the real saw.
- Tracking: Moving around the hologram, it maintains its position with respect to the saw.
- Remote support: The Hololens is able to connect to external devices via wifi. It was shown that the Hololens could connect to a laptop, which represented the workstation of a remote service technician. The service technician can communicate through the laptop microphone and speakers with the Hololens wearer. He/she can also see the same scene viewed through the Hololens (both real world and hologram), and can control which holograms are viewed,

bringing up models of the internal components of the saw. Pointing arrows are included to aid with discussions.

Fig. 3: A holographic model of internal components is shown projected on the outside of the mock-up Bladestop saw.

The University application was then used as a model to bring the required technical skills into Scott to develop further applications. This proved more difficult than originally thought, and a new staff member with a Masters in Computer Science was recruited to upskill in this area.

A second application was developed, in which the Hololens wearer can reference to a Leap lamb boning system (configured initially to the Brooklyn system) and can view components from the system. Additional features introduced in this development:

- The application is developed around the standard machine manual, which is normally presented in paper or 2D pdf format. The manual can be placed at the desired location within the scene, and the wearer can turn pages by clicking on the forward or back arrows. Links within the manual allow the wearer to "turn" to a particular page (e.g. to a particular section from the contents page) or to turn on holographic 3D views of components and sub-assemblies.
- Components being viewed can be dragged from their accurate location to an alternative location for a closer inspection away from the real machinery.
- Referencing is being re-investigated to provide a low-cost (or free) add-on, as the University's solution involves Vuforia, which is an expensive licenced application.
- Remote support has been extended to allow an external network, enabling the support technician to be sited anywhere worldwide. Ongoing work is continuing, to improve stability of this connection.
- The application has been configured to work for very large files. Models are not stored within the Hololens, but are uploaded via the wifi network in a compressed format, and are extracted for use only when they are needed.
- Further development went into simplifying the process of adding holographic models to the application, in order to shorten the time to develop applications.

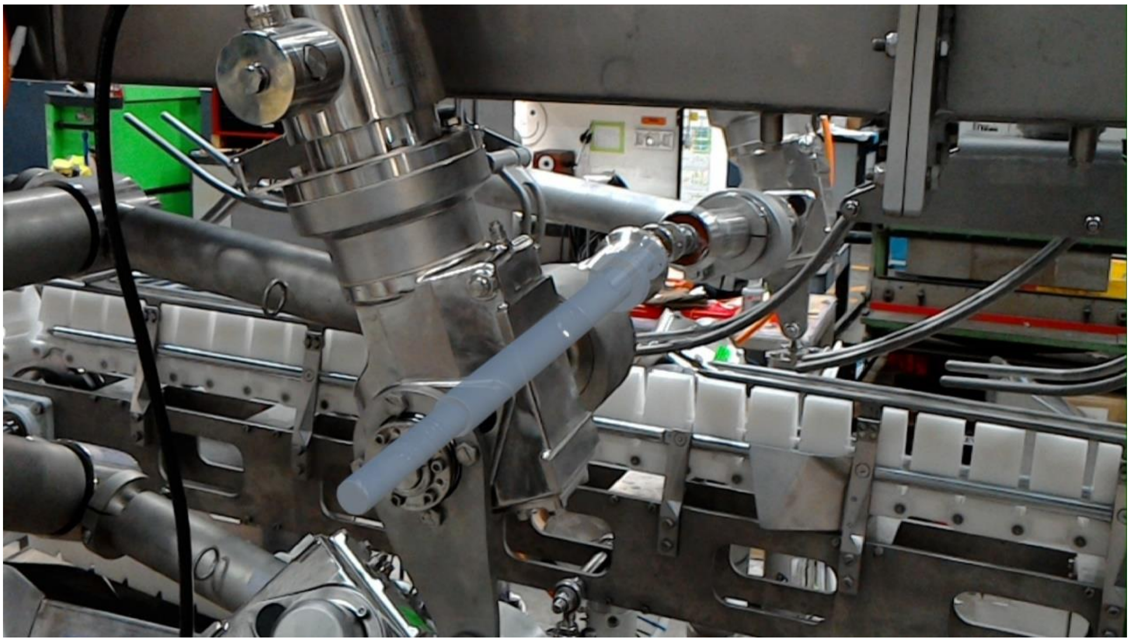

Fig 4: The shaft of the top cutting unit in the Leap system Chine station.

3.3 Objective 2

It was intended to stage a demonstration of the Hololens maintenance application at the Brooklyn site in order to introduce the technology to the industry and gain further feedback. This has not been possible due to the timing of the Leap system commissioning. However it is still intended to include this in an industry open day at a later date as part of the Leap project.

Some industry demonstration has occurred throughout the project however. With development happening in the Scott facility it was possible to take advantage of a Leap system being built there at the time for testing of the Hololens. When a customer engineer was at Scott to gain familiarity with the machine, he also trialled the Hololens, giving feedback on its further development. A Hololens was also brought to the Brooklyn site under Scott charge to test it in the site conditions. This was also trialled by a Brooklyn engineering staff member, providing very valuable feedback which helped shape the continued development.

3.4 Objective 3

MLA project P.PSH.0911 involved development of some concepts for beef boning automation and sharing these with a representative group from the Australian beef processing industry. The 3 concepts produced were modelled in 3D in Solidworks.

It was found that the Visual Components' simulation software package that Scott already has includes an interface to save animation sequences as a virtual reality file which can be viewed and controlled over the commonly used Steam application. Steam is a free app, and has interfaces for most major VR devices including the Windows Mixed Reality units.

In order to display the P.PSH.0911 concepts in VR, sub-assemblies from the Solidworks model were imported into Visual Components, allowing them to be reassembled in a flexible manner. An animation sequence was then prepared and saved as a VCAX file.

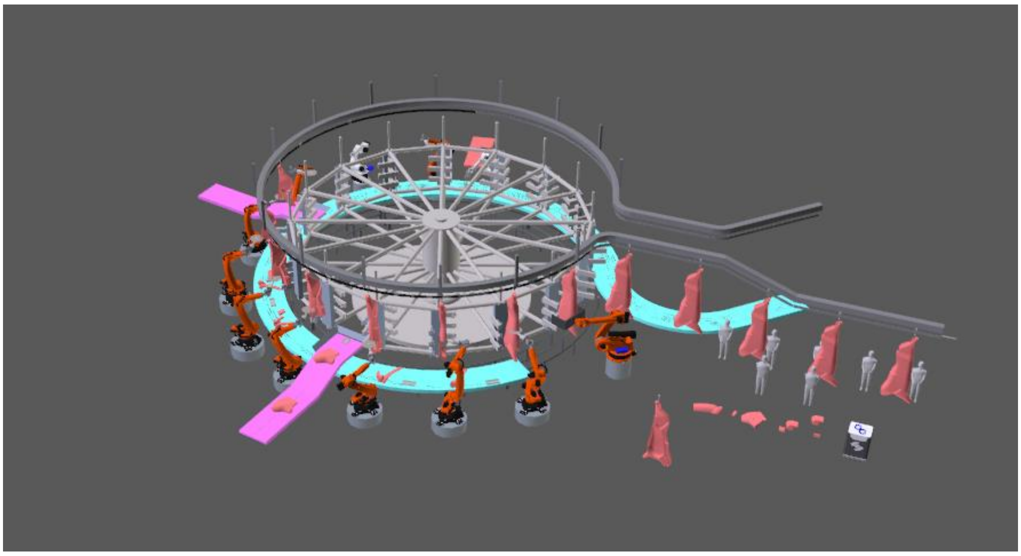

Fig 5: Carousel Concept from Visual Components.

3.5 Objective 4

With Objective 3 already demonstrating how to display a modelled virtual layout, for Objective 4 we turned to 360 video. 360 video gives the illusion of 3D when viewed within a VR headset as the wearer can control their viewing direction by turning their head. However it is actually a form of panoramic videoing in which the video camera records the entire scene around it. Motion of the camera operator is displayed in the VR application, giving the illusion of moving through a scene (or of having the scene moving around you).

A professional videographer was contracted to record a 360 video through the Brooklyn Leap boning installation. He staged the video as a walk-through of the room, mounting the camera on a pole to have it recording from a height.

The video produced was displayed on Windows Mixed Reality headsets at the MLA AGM and Red Meat Industry Forum at Alice Springs, in November last year.

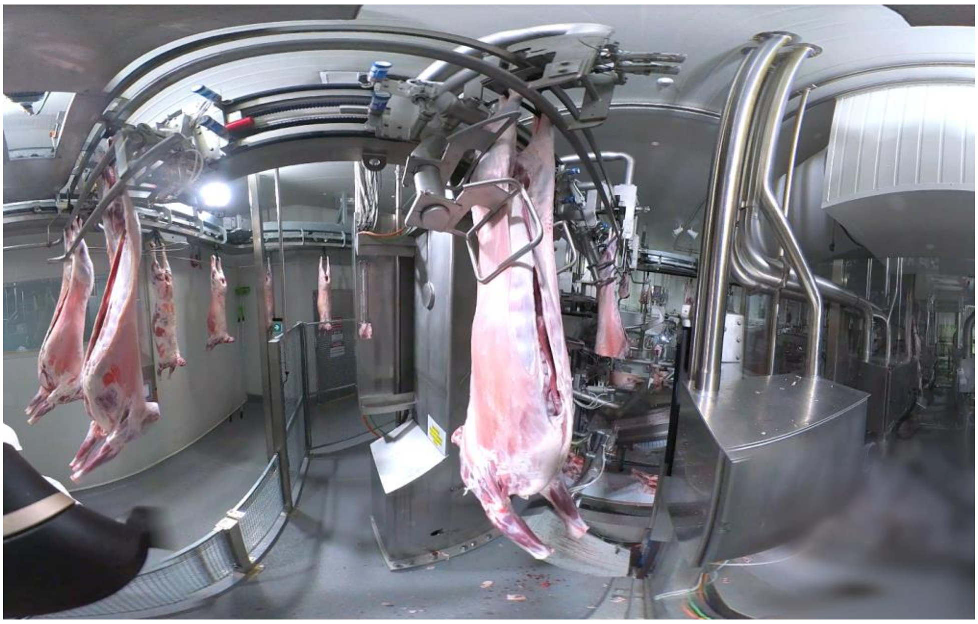

Fig 6: 360 'Flythrough' at Brooklyn, shown with the characteristic fish-eye distortion when viewed un-flattened on a 2D screen.

4 Results

4.1 Initial Investigation

The investigation confirmed that the AR/VR industry is evolving rapidly, and notably does not yet have a clear standard platform (or platforms). This parallels the computing industry, in which an early multitude of platforms eventually narrowed to PC and Apple Mac. Many AR/VR companies have entered the market with a lot of promise, and have not succeeded. It is therefore very important to try to pick a company likely to become established in the industry.

The most established companies currently are Google, Facebook and Microsoft. Google has the low-end "make your own" Google Cardboard headset, as well as some other mobile phone based headsets. Facebook has the Occulus product range (including Rift and Go) which range from phone-based to PC-tethered. Microsoft's high-end offering is the Hololens, which is an AR device with computing power built-in. Microsoft also has the Windows Mixed Reality platform, in which partners Acer, Dell, HP, Lenovo, HTC and Samsung have produced PC-tethered VR headsets. Each of these companies has a strong presence in the industry, but to generalise Google is focused on the low-end consumer market, Facebook on the high-end/gamer market and Microsoft on solutions for industry. For that reason, we have chosen to focus on the Microsoft offerings, using the VR headsets for situations where we want to control the entire environment from a static location and the Hololens for when we want to view imagery in the real environment, including being able to move around in it.

4.2 Objective 1

The applications developed for Objective 1 demonstrate the potential of the Hololens as a machine maintenance tool. The key results of this work are:

- Models can be referenced to the real world machine in order to display these in an accurate position on the machine.
- Connection with a wifi network enables the display of selected components of a large application.
- Viewing can include the ability to manipulate models and move these to different locations.
- The full machine maintenance manual can be viewed in the headset, with easy navigation. This forms a useful template for developing an application as well as an effective means to navigate.
- Remote support is a particularly useful feature of the system, allowing the Hololens wearer in the processing room to be working with a remotely located technician as if they were right with them.
- The large effort involved in this development has resulted in a template for more easily creating future applications.

4.3 Objective 2

All industry feedback received on the maintenance application has been very positive, with people trialling it being able to clearly understand the benefits of the technology for their future use. In particular the remote support is a very important feature, enabling the engineer to call up virtual on-site support at short notice rather than having to wait for a visit and pay for travel costs, or try to work through phone support.

Negatives related to hardware and ease of use. In particular, the Hololens narrow field of view was noted (something we anticipate being addressed in the next generation Hololens) and wearing the Hololens made it difficult to wear a hard-hat (Hololens-compatible hard-hats have since been located). Ease of use issues are being addressed through ongoing development of the application.

4.4 Objective 3

The Beef Boning concept animations have been viewed in virtual reality on Scott's Windows Mixed Reality headsets by Scott and MLA staff. The hand controllers give the ability to "teleport" to selected locations within the layout, while head/full body motion allows the wearer to change their viewing direction within the model.

The VR environment proved very effective in helping the wearer to appreciate the full scale of the layouts. The animation was a bonus, showing quite clearly how the concept is intended to operate. Because this method of generating a VR application involves existing software which Scott staff are familiar with, and which relies on modelling rather than programming for development, it is a very effective method to create applications for VR.

4.5 Objective 4

Like the simulation, the 360 video was a very easy application to produce, creating an effective output medium. It gives the impression of being in the scene, and headset wearers have been witnessed swerving or ducking to avoid perceived obstacles. Wearers were encouraged to sit on a swivel chair during viewing, allowing them to move their view direction easily while maintaining their balance.

The videoing method could be refined further, with an eye on how the video will be viewed. In particular that involves walking more slowly through the scene, turning slowly, and managing video transitions carefully to avoid disorientation.

5 Discussion

At its heart, AR & VR can be considered as communication tools for the industry. They provide a new way of viewing imagery which is realistic, making it easy to visualise. The added value of being able to communicate remotely through AR headsets is immense, providing very fast access to technical experts when they are needed.

What became obvious from our investigations is that VR is close to mainstream with application developers providing quite easy ways for people who are not software developers to produce quite high-end VR outputs (e.g. applications such as Visual Components).

AR is less mainstream, with a limited number of headset providers, and fewer customers (due partly to the complexity which results in a higher pricetag). There are some applications emerging in which AR outputs can be produced with minimal skill, but these are limited in complexity. Consequently users are still engaging software professionals to develop their own custom applications to suit their needs. Our intention with the maintenance application is to be a template that can be used to create other maintenance applications from, but this will still require a degree of software programming skill.

Applications we have produced have all been very successful and will be deployed in industry in a short timeframe. We have yet to complete a full industry demonstration of the AR application, but limited demonstration has been very encouraging, and fine-tuning has been able to address any software-based concerns.

The following describes the extent to which project objectives have been met.

5.1 Objective 1

Objective 1 has been completely achieved, based on ensuring all elements have been developed for use in at least one case and functionally proven. Further extension of this objective will be to apply all elements more widely.

5.2 Objective 2

It makes most sense to do the full industry demonstration of the AR system in conjunction with the tentatively planned open day at Brooklyn to showcase the Leap system installed there. Timing of that project has meant that this is not possible within the contract timeframe of the AR project and so we have chosen to do this outside of the MLA project. However some demonstration has been possible at various stages to select individuals.

5.3 Objective 3

Visual Components proved to be a very effective way of converting the beef automation concepts to virtual reality, and the ability to animate this made it an extremely effective medium. We were easily able to achieve this objective.

5.4 Objective 4

Objective 4 was perhaps the easiest objective to achieve, requiring only a 360 camera and some filming. A focus for future improvement will only be in ensuring a natural flow that more easily follows the way a person would naturally walk.

6 Conclusions/recommendations

The key insights from this project are:

- VR and AR technologies promote better visualisation of plant and machinery. Details are readily recognisable, and the headset wearer can walk around them and view them from all angles.
- The remote connection provided within the AR format is an effective way of bridging issues of remoteness for technical support.
- VR applications in particular are readily available for adoption.
- With an initial investment in application template development, AR applications can be rolled out reasonably easily with a medium level of skill.
- The machine manual is a useful starting point for developing an interactive AR machine application.

Our plan is to use VR widely in sales & marketing initiatives. Sales people will take VR headsets with them for customer presentations in order to showcase concepts and benchmark machinery. Similarly these will be used at tradeshows.

Initial thoughts are to ensure each customer has at least one Hololens AR headset at their plant in order to use with a maintenance package. These would either be provided to the customer upon sale of a machine or leased as part of a service package. Such a service package could provide access to around the clock technical support.

We see the biggest improvements to the meat industry being:

- Ensuring clear communication around plant and machinery layouts/specification.
- Avoiding delay for service support, particularly for remote locations.
- Assisting with technical training as well as reducing the degree of technical competence needed for on-site staff.

We encourage widespread use of AR and VR within the meat industry to achieve the improvements noted above. Other uses for the technology to explore include training for machinery use and training for meat processing.

7 Key messages

- Suppliers should be able to display proposed equipment and layouts in virtual reality. This will aid processors' visualisation.
    - Decisions can be made easier and quicker.
- Augmented reality can be used as a tool to understand complex machinery, both for training and service requirements. Remote support through these devices enables rapid call-out support regardless of location.
    - Required on-site maintenance skills can be lower.
    - Physical call-outs should be less frequent, replaced by virtual call-outs.