AUSTRALIAN MEAT PROCESSOR CORPORATION

FINAL REPORT: Wearable Technology for the Red Meat Processing Industry

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1.0 Executive Summary

This report documents the results of an investigation to determine if red meat processing facilities would benefit from the use of wearable technologies.

Wearable technologies offer the ability to sense, autonomously interpret and communicate information in a portable and unobtrusive manner. These traits make it possible to exploit a worker's proximity, location and/or perspective in order to acquire new information about the worker, the product and/or processes in real time at every step in the supply chain.

The project involved a review of the published literature on wearable technology and the food and manufacturing sectors in order to identify existing wearable technologies that would be of use inside the red meat processing factory. This review was accompanied by an interview with representatives from a meat processing business.

In addition to the literature review, AMPC and CSIRO organized a workshop in order to raise awareness of wearable technologies across AMPC, AMPC members and partners and to obtain feedback on initial applications of wearable technology within the red meat processing factory.

As a result of these tasks, three potential applications of wearable technology have been identified which have buy-in from AMPC members and partners. Three additional applications have been proposed by the report author. The proposed applications address problems in quality assurance, human resources, facility management and health and safety.

2.0 Introduction

Wearable technology offers a portable platform in which to deploy applications that sense, autonomously interpret and communicate as is done now with a modern smartphone. Unlike smartphones, wearable technologies are not constrained by the dimensions of the phone and thus offer new and interesting avenues for performing tasks in the workplace.

The goal of AMPC Project 2016.1048 was to identify wearable technologies that would improve the information used by employees to make decisions about the product and/or processes inside a red meat processing factory.

This final report report contains the following outputs of the project:

1. A review of scientific and business literature (including Australian Meat Processing Corporation and Meat and Livestock Australia reports) that involve wearable technologies in industry.
2. A summary of an interview conducted with industry representatives in order to identify areas within the red meat processing factory which could potentially benefit from wearable technologies.
3. Initial potential applications of wearable technologies in Australian red meat processing built using the information captured in the literature review and interview.
4. A description of the workshop held with AMPC, AMPC members and partners to raise awareness of wearable technologies and to provide an opportunity for stakeholders to provide feedback.
5. A summary of the future directions for wearable technologies identified by workshop attendees.

3.0 Project Objectives

3.1 Review of Scientific and Business Literature

3.1.1 Foreword

Wearable technologies represent a small component of much larger paradigms such as the Internet of Things, Cyber-Physical systems, Cloud Manufacturing and Industry 4.0. These paradigms broadly represent a push towards connecting the physical world and the digital world [37, 47, 41, 45].

Wearable technologies contribute to this amalgamation by providing a portable human centric platform where information can be shared. Wearable technologies can sense, autonomously interpret and communicate as is done now with a modern smart phone. Unlike smart phones, wearable technologies are not constrained by expectations on physical dimensions and interfaces like touch screens, microphones and speakers.

"The key difference between current mobile computing devices and wearable computing devices, however, is the reduction of the centrality of a physical screen in order to achieve tasks" [44].

Comparing wearable technology to smart phones illustrates another trait of wearable technology. It is very common for a person to own a mobile phone and have it on their person for the majority of the day, however, it is very uncommon for a person to carry two phones. The literature on wearable technologies predicts that the expected number of wearable technologies that a person will wear is far greater than one [42]. The wearable devices available today already suggest this to be true for the consumer sector based on the availability of smart watches, smart glasses, smart rings and smart clothes. However, it is unclear what expectations there are for the industry sector. It is even more uncertain for food industries as the technology has to abide by stringent workplace standards e.g. foreign particle risk mitigation via tethering of equipment.

The ability for wearable technology to sense, interpret and communicate highlights the breadth of technology that underpins wearable technology. This flexibility creates a number of challenges when evaluating wearable technology for deployment in the meat processing industry.

Firstly, the sensing, autonomous interpretation and communication capabilities are orthogonal, producing combinations where individual technologies may be at different levels of industrial readiness.

Secondly, there exists challenges pertaining to the communication capability. Wearable technology is intended to provide information to external entities or to present information from external entities or a combination of both. For digital communication, there are costs associated with maintaining this communication channel e.g. compatibility with existing infrastructure and software, security, quality of service, error tolerance, energy requirements, network utilisation and network contention [47].

Thirdly, the communication capability greatly increases the number of potential scenarios where wearable technologies would be of benefit. The meat industry could approach an evaluation of wearable technologies by enumerating over the current tasks performed in the industry and determine if any can be improved using wearable technology. This approach does not entertain scenarios where the productivity of two or more currently independent tasks are improved by a coupling created via wearable technology.

These challenges highlight the difficulty in performing a review which targets the meat industry specifically. It also highlights the tremendous flexibility that wearable technology, and its parent paradigms, can offer the meat processing industry.

The scope of the literature review was restricted to the meat processing factory. One of the questions raised during the review of the reports available from the Meat and Livestock Australia [32] and the Australian Meat Processor Corporation [30] is what future role do employees have within the industry given the existing and ongoing research in to factory automation?

A second difficulty encountered with the review is concerned with the size of the meat processing industry. The number of processes meat processing factories perform simultaneously is substantial e.g. producing primal cuts, value adding, workplace health and safety, waste management and employee training. Determining to what extent employees are involved in each of these processes and determining if wearable technology would be of any benefit is difficult to ascertain from the MLA and AMPC reports and business literature alone.

Addressing these unknowns can only be achieved through stronger collaboration between the research and development sector and the meat processing sector. In response to these issues, the report author broadened the literature review to include examples where wearable technology is, or is expected to have, an impact in other industrial sectors.

The rest of this section is divided in to high-level groupings of current industrial applications and research of wearable technology.

3.1.2 User Augmentation

Wearable technologies can be used to provide wearers with real-time information. This information can be communicated a number of ways e.g. a chemical reaction resulting in a colour change [34], a wearable display (rigid [28] or bendable [20]) or smart glasses.

Smart glasses are a pair of glasses with the ability to overlay information in the perspective of the wearer. The major attraction of smart glasses is that there is no physical screen which the user has to hold. It provides “a medium which remains transparent until the wearer needs to notice it, becoming present for access to contextually enriching, even perhaps crucial, data.” [44, 46]

The availability of smart glasses has spurred a great amount of research and investment in to novel applications of the technology e.g. [37, 31, 29].

One of the target applications for smart glasses is improving how tasks are assigned to employees working in warehouses. Using smart glasses, an employee can be continuously updated with information of customer orders. If the smart glasses include a camera, then the smart glasses are capable of performing other tasks such as barcode scanning or act as a warehouse navigation aid when locating assets and/or stock. Examples of this use of wearable technology can be found in [29, 2, 3].

The presence of the camera also allows businesses to use the perspective of the user as a service. This perspective can be used to perform tasks such as autonomously obtaining measures of product quality and/or recording the locations of factory assets on the behalf of all staff.

Smart glasses with display, camera and communication capabilities provide opportunities for real-time training and maintenance support applications [37, 31, 2, 21]. In this instance, the wearable technology provides factory employees with quick access to domain experts. The smart glasses also provide the domain experts with the visual perspective of the wearer which allows the expert to see the reported issue. Importantly, this two-way communication channel allows the wearer of the smart glasses to use his hands and body for other tasks [37, 35].

The ability for smart glasses to overlay information in the perspective of the wearer has created interest in developing new types of training systems. These new systems place virtual instructions on top of the equipment which is in need of repair or assembly. An example of this is provided in [21] where a pump is to be repaired. The smart glasses provide details such as which bolts are to be removed and a visualisation demonstrating how to safely disconnect the main body of the pump.

The medical industry contains products which use smart glasses to provide information that a practitioner cannot perceive. The Evena Eye-Glasses 3.0 [12, 13] allows a nurse to see blood flowing through veins in real-time. This information is used by the practitioner to select the best vein in which to insert a needle. This use of smart glasses can be adopted for other modalities which a human cannot perceive e.g. magnetic resonance images, X-ray images, sonograms or thermal images [10].

Haptic technology provides the wearer with digitally controlled touch sensations. This technology has been demonstrated to allow deaf people to “hear” words using a vest [11] and there are also products which allow users to feel virtual objects via gloves [8, 7, 16].

3.1.3 Machine Instruction

There are instances in the literature which involve humans instructing machines. An example from meat industry reports is [39] where a semi-automated beef scribing system is proposed. The human operator required for the system uses a PC terminal to plan a cut which is then executed by a robotic system.

Wearable technology has been demonstrated to communicate instructions to machines in a hands free manner. The work in [35] showed that hand gestures acquired using a special glove prototype can be used to control a mouse. It is possible to simplify this idea further and use hand gestures to communicate application specific actions like “next item” or “previous item”. Examples of more advanced hand gesture identification systems suitable for these application areas can be found in [23, 6].

If it is not possible for the employee to wear gloves then there exists other wearable technologies for gesture recognition e.g. muscle sensors [18, 5] and body gestures [25].

3.1.4 Health and Safety

A very active application area for wearable technologies is in the area of health and safety.

The work of [40] demonstrated that a waist worn tri-axial accelerometer could be used to detect when people fall. This device is useful in retirement villages and hospitals where staff can be automatically notified of incidents involving residents or patients.

A prototype system [25] showed that wearable technology could be used to estimate the pose of the human body and other wearable items such as glasses. This prototype was developed for mining applications and was able to detect potentially hazardous configurations such as not wearing safety glasses. A similar system was used in [36] to perform gait analysis in order to quantify the impairment level of hemiplegic patients.

Other examples of wearable technology for health and safety applications involve detecting poor air quality [38], dangerous gasses [33, 26], radiation monitoring [17] and UV exposure [24].

The meat industry has conducted research into a bandsaw safety system [27]. This system, titled VisionStop, requires the operator to wear special gloves which a purposely built vision system can use to identify when the operator’s hands have entered a “contact zone” and automatically trigger an emergency stop of the bandsaw.

There are industries where employee drowsiness or micro-sleeps can cause major injury and/or fatalities e.g. truck drivers or operators of mining equipment. Wearable technologies have been developed which can detect signs of drowsiness and trigger alarms [19, 22, 15]. Similar technology has also been used to measure athlete performance [14].

The law enforcement and correction industry employs wearable alcohol monitoring technology to monitor sobriety of individuals as dictated by the courts [4].

Lastly, a different form of wearable device, the Cyberdyne Lumbar support wearable device [9], is available to reinforce the lumbar region of the wearer when lifting heavy equipment.

3.1.5 Measurement and Quality

Wearable technology that records the body pose of the wearer (e.g. [25, 40]) provides opportunities to evaluate performance of specific tasks. One problem encountered in the medical industry pertains to the rate of improvement for patients with osteoarthritis [43]. The exercises for this condition are such that the patient has difficulty seeing the reward for their effort. This lack of feedback results in a decrease in motivation. Wearable technology was demonstrated to be able to provide patients with data showing progress and thus help maintain enthusiasm for the exercises.

A wearable camera also provides opportunities to use computer vision algorithms to autonomously obtain measurements of an employee's ability to execute a task. This measurement could then be presented to the employee (using smart glasses), producing a real-time feedback loop of progress and capability development.

3.2 Interviews of Meat Processing Representatives

A number of interviews with people from the meat processing industry were to be performed as part of this project. These interviews were designed to get people working in the industry to identify areas within the meat processing factory which would benefit from wearable technology.

The interviews were structured to try and obtain information pertaining to the following questions:

- Could wearable technologies be used to improve how tasks are assigned to employees?
- Could wearable technologies be used to improve workplace, health and safety?
- Could wearable technologies be used to provide training to employees?
- Could wearable technologies be used to improve the way in which employees communicate with machines?
- Could wearable technologies be used to improve employee performance by presenting information which cannot be perceived directly?
- Could wearable technologies be used to measure the performance of employees and manufacturing processes?
- What future role do employees have in your business given the investment in automation?
- What procedures does your business use when investigating potential innovations in workplace processes?

Given the relative immaturity of wearable technology and the potential lack of awareness within the industry about the capabilities of wearable technology, the interviews were designed to stimulate discussion on wearable technology. The material prepared for the interviews was sourced from the citations used in Section 3.1.

Only a single interview could be conducted in the time available for the project. A summary of this interview is provided in Section 3.2.1.

3.2.1 Interview 1

This section provides a summary of an interview held with representatives from a meat processing business. The representatives interviewed were responsible for current and future product development and human resources and safety.

Wearable Technologies for Task Assignment

The representatives were unable to provide any cases where the business would benefit from using wearable technologies to provide real-time task assignment to employees.

Wearable Technologies for Health and Safety

There is a need within the human resource department for improved knowledge of worker location. This information is required in emergency situations e.g. an evacuation.

The representatives showed interest in assistive technologies like the Lumbar Support product by Cyberdyne [9].

Wearable Technologies for User Instruction

The representatives saw opportunities for wearable technologies to improve their worker certification programme. An employee is required to be certified for a particular task before they are allowed to work in the factory. The certification is renewed periodically, termed *recorrelation*, in order to maintain competency and consistency across the workforce. Wearable technology is thought to be applicable for the following use cases:

1. Showing the employee how to perform a task. (Initial certification and renewal).
2. Providing real-time evaluation of performance. (Initial certification and renewal. There is potential for such a system to be deployed in the factory to collate real-time measurements of employee efficiency and product quality).

The Human Resource department manages a large number of certification processes.

Wearable Technologies for Machine Instruction

The representatives were unable to provide any cases where using wearable technologies to communicate instructions to machines would improve current processes.

Wearable Technologies for User Augmentation

The representatives were unable to provide any cases where the output of a task would be improved by presenting the employee with information, which cannot be sensed by a human, prior to performing the task e.g. X-ray, sonogram or MRI.

Wearable Technologies for Hands Free Communication

The representatives responded positively to hands free communication devices. No immediate application was described, however, it was anticipated that an inspection of the factory would identify opportunities for such devices.

Wearable Technologies for Measurement and Quality

The representatives articulated that the processes for obtaining quality assurance (QA) measures are slow. In many situations, the time taken to acquire the measures allows the suboptimal processes to continue to completion i.e. past the point of being able to affect change. A system is desired which provides real-time QA measures in order to reduce the impact of poorly performing processes.

A system was desired which collated the following information:

1. When did an employee enter and/or leave an area?
2. What tasks did an employee perform in this area?
3. How well did the employee perform these tasks?

This information would be useful to other aspects of the business e.g. payroll, employee efficiency, health and safety procedures.

Employee versus Automation

The representatives stated that people will always be present in factories as there are tasks which a machine cannot perform e.g. machines, trialled by the business, have difficulty accommodating the variability in cattle structure. Adapting to this variability is a key part of their business and is why humans will always be present in the factory.

Process Innovation

The business invests heavily in process improvement. The business has trialled different processing techniques in the past and will continue to do so in to the future. The business' experience with process experimentation has shown that time is required for a new process to achieve the expected improvements in efficiency. Experimentation with wearable technology would undergo the same procedure.

Other Notable Messages

The topic of camera based technology was discussed during the interview. Specifically, technologies involving computer vision algorithms. The business has trialled computer vision based systems previously. These systems were found to be inferior to other methods of performing the same task.

3.3 Initial Applications of Wearable Technology

This section outlines potential applications of wearable technology in the meat processing industry. The applications outlined are based on information obtained during the interview with industry representatives. The applications are conceptual in nature and no estimate of effort is provided.

3.3.1 Employee Training and “Recorrelation”

An application identified during the interview is to incorporate wearable technology in to training and certification programmes.

The application envisaged is to have trainees wear smart glasses, which can:

1. Play a video showing the correct way to perform a task.
2. Record the trainee performing the task.
3. Autonomously provide real-time feedback of the trainee’s performance.

Using smart glasses to demonstrate the correct way to perform a task is expected to have a number of benefits. Firstly, the employee can be holding the correct equipment whilst watching what has to be done. Secondly, the perspective of the instructional video will be similar to the perspective of the trainee allowing the trainee to build an expectation of what should be seen when performing the task.

Recording the employee performing the task provides a feedback loop to the trainee and the training staff. The trainee has the opportunity to replay their previous attempt in order to better understand the outcome. The training staff can also use the recording to provide better guidance to the trainee. The recording can also be archived and used as evidence during reviews of training procedures.

Providing autonomous real-time feedback to the trainee could help reduce the time needed for training. There is also the possibility of reducing the amount of training staff required to train new employees.

It may be possible to use this system to consolidate the training programme into one location. Training a new employee would involve communicating with a remote trainer via the internet. The use of smart glasses would allow the training staff to see and hear everything the trainee can see and hear.

3.3.2 Employee Tracking

The human resource department of the business which participated in the above interview is required to show proof that an area is free of personnel in emergency situations. Satisfying this requirement would be simpler if staff were wearing a device which could be tracked across the entire site. Determining if individuals were in the affected area would be as simple as looking at a real-time map showing the locations of each employee.

The human resources department could also use the tracking technology to determine when an employee entered and exited an area. This data would be useful for recording work hours and for security purposes.

3.3.3 Employee Performance and Quality Measures

Wearable cameras and body pose estimation technology could be used to provide measures of employee performance and product quality.

A wearable camera could be used to obtain measures of product quality by autonomously inspecting recorded footage of the employee. These quality measures could then be:

- communicated to subsequent stages of production in real-time.
- communicated to managers for workforce evaluation.
- communicated to the human resource department as data points measuring the effectiveness of training and certification programmes.

3.4 Workshop with AMPC, AMPC Members and Partners

A workshop was included in the project to provide an opportunity to introduce AMPC, AMPC members and partners to the capabilities of wearable technologies and to talk directly to researchers working in the area. The workshop also provided an opportunity for stakeholders to provide feedback about the technology and to communicate other areas of a meat processing facility that should be of focus for AMPC and research organisations.

The workshop was held on the 6th May 2016 at the Queensland Centre for Advanced Technologies.

The following speakers presented at the workshop:

John McGuren (AMPC)	Workshop and project introduction.
Dr Mark Cox (CSIRO)	Wearable technology overview.
Craig James (CSIRO)	Smart glasses, augmented reality, virtual reality and wearable displays.
Dr Raja Jurdak and Karl Von Richter (CSIRO)	Wearable sensors and distributed sensor networks.
Dr Elliot Duff (CSIRO)	CSIRO, Future Manufacturing, Industrial 4.0, Internet of Things.

3.5 Workshop Feedback and Future Direction

The following list contains the important subjects raised during the workshop:

1. Cultural issues.
   (i) People will initially see the technology as a step towards replacing people.
   (ii) Wearable products which track an employee's pose or location for training purposes will evoke a hostile response. Past experience of the attendees suggests that the products would be circumvented in some manner or purposely broken.
   (iii) Steps need to be taken to ensure employees see the value in the technology. There must be buy-in from the employees.
2. Wearable technologies are seen as a mechanism for attracting the younger generation to the industry.
3. There was a general consensus that wearable technology would allow employees to make better decisions in a shorter amount of time.

One business was already using smart glasses for training new employees. This business had a number of videos which were required viewing for new employees.

The rest of this section outlines the three potential applications of wearable technology which were proposed during the workshop by representatives from the red meat processing industry.

3.5.1 Quality Assurance

Wearable technologies were identified as being useful for improving the collection of measurements pertaining to product quality and health and safety. Participants saw opportunities for wearable technologies to improve the quality of the data inputted in to the system by employees (errors in this data should be zero) and for employees to make better decisions in a shorter amount of time.

Regulations require meat processing facilities to periodically perform a number of process and product checks e.g. hygiene and condition of the product and equipment. One meat processing businesses currently collects this information by:

1. Using a tablet computer to fill out the equivalent of twelve A4 sheets of forms.
2. Using the tablet computer to capture photographic and/or video evidence of the product and/or equipment (videos are up to 15 seconds in duration).

This data is immediately sent to information management systems (e.g. iLeader by InformationLeader) in order to satisfy direct data entry and auditing regulations.

The data entry performed by staff includes ticking boxes and typing sentences which describe the state of the product and/or equipment.

The main issue with the current data entry procedure is that it requires staff to carry a tablet computer. Smart glasses were seen as an opportunity to use a device which does not impact on the ability of staff to use their hands.

An important issue raised during the workshop was the lack of keyboard interface provided by smart glasses. A keyboard interface is required to efficiently enter a description of the product and/or equipment.

Workshop participants also saw value in using smart glasses to present a *dashboard* to quality supervisors. The dashboard would display to the quality supervisor a summary of the current state of production across the entire facility (omnipresent supervisors) and the ability to be immediately informed of critical events in *real time*. It was also desired that the smart glasses had the ability to present only the most pertinent information for the current location/context e.g. a sausage room dashboard.

3.5.2 Facility Maintenance

Meat processing businesses employ staff and contractors to perform maintenance on processing facilities. These workers are typically issued with task specific information such as the work order, facility procedures and product manuals. This information is usually provided to the worker in print form.

Workshop attendees showed interest in having this information provided to the worker via smart glasses. This would (i) alleviate the need to carry the information (ii) businesses would no longer have to manage physical assets like procedures and manuals and (iii) the information would always be immediately accessible by the worker.

The photo and video recording capabilities of smart glasses would allow the workers to record evidence before and after work was performed.

The video capture, display and communication capabilities of smart glasses would allow the worker to establish a two-way communication channel with an expert in unexpected circumstances.

3.5.3 Mitigating Health and Safety Risks

A use case identified at the workshop involved using wearable technologies to mitigate health and safety risks for a specific group of employees.

Some meat processing facilities require a small number of employees to monitor facility operations. These employees spend approximately 80% of their time away from their offices in order to perform their duties. During this time, the employee may be inadvertently exposed to dangerous levels of gases (e.g. ammonia, hydrogen sulfide or oxygen) or be involved in an accident which renders them immobile.

Participants at the workshop desired a wearable device that would reduce the health and safety risks to these staff. The desired device would:

1. Trigger an alarm when an employee was autonomously determined to be immobile and/or had fallen over.
2. Trigger an alarm when the employee is at risk of being exposed to dangerous levels of specific gases.
3. Provide the employee with the ability to manually trigger an alarm.
4. Track the employee throughout the facility for the purposes of directing emergency response teams.

Such a device would reduce the time taken to trigger an emergency response and reduce the time taken to find incapacitated staff.

4.0 Methodology

The purpose of this project was to identify use cases within the red meat processing factory where wearable technology would be of benefit. The project was conducted in a manner to encourage knowledge transfer between AMPC, AMPC members and partners and research and development teams involved with wearable technologies. This was achieved, with guidance from AMPC, by writing a literature review on wearable technologies in industry, conducting an interview with representatives of the red meat processing industry, and hosting a wearable technology workshop for AMPC members and partners.

No experiments, measurements or statistical analysis was performed in this project.

5.0 Project Outcomes

The project outcomes of AMPC project 2016.1048 are:

1. A review of scientific and business literature (including Australian Meat Processing Corporation and Meat and Livestock Australia reports) that involve wearable technologies in industry.
2. A summary of an interview conducted with representatives from a meat processing business in order to identify areas within the red meat processing factory which could potentially benefit from wearable technologies.
3. A summary of three future directions of wearable technologies in Australian red meat processing developed using the information acquired from the literature review and the interview with industry representatives.
4. A description of the workshop held with AMPC, AMPC members and partners to raise awareness of wearable technologies and to provide an opportunity for stakeholders to provide feedback.

5. A summary of three future directions identified by workshop attendees for developing wearable technologies for red meat processing facilities.

6.0 Discussion

A difficulty encountered when performing the literature review is the limited written material describing the tasks that staff perform today inside a red meat processing facility. Furthermore, from the perspective of the red meat processing industry, investing in wearable technologies is an investment in people. Having a road map for personnel in the red meat industry is important as it reduces the risk of overlapping with investments in other research and development domains such as robotics automation.

The feedback from the wearable technology workshop was very positive. The workshop appeared to address a high amount of uncertainty over the usefulness of wearable technology inside a meat processing facility. The workshop organizers commented that there was a high amount of goodwill among the workshop participants.

One of the directions identified during the wearable technology workshop involves using smart glasses to improve how data about product quality is obtained. Current implementations of regulations require employees to use a keyboard interface to record a custom description of the product and/or equipment. Unfortunately, smart glasses are unable to provide a keyboard interface like the interface provided by tablet computers. Satisfying this input requirement whilst exceeding current levels of productivity is one of the challenges that needs to be addressed when pursuing smart glasses.

An alternative solution to the keyboard interface requirement would be to introduce changes to the regulations such that a custom description is replaced with an alternative. Which regulation body requires the custom description is unknown at the time of writing, however, an informal discussion with a representative from the Queensland Department of Agriculture, Fisheries and Forestry indicated that the department is open to discussing changes to the regulatory requirements in order to accommodate productivity gains from technologies which do not have a keyboard interface.

7.0 Conclusions/Recommendations

AMPC project 2016.1048 was undertaken to determine if wearable technologies would be of benefit to red meat processing facilities. The project involved performing a literature review of wearable technologies with potential application to red meat processing facilities, conducting interviews with AMPC members and partners and organising a wearable technology workshop which allowed AMPC members and partners to communicate with researchers in the area of wearable technologies.

This project report includes six future directions for the industry based on the feedback provided during interviews and the wearable technology workshop. The potential applications address problems in quality assurance, human resources, facility management and health and safety.

The cultural issues identified in the workshop indicates that the industry must have a strategy for introducing the technology to its employees. A hostile reaction to the technology will have lasting consequences and impact the return on investment.

Four out of the six proposed future directions involve the use of smart glasses. The ability of the device to push, pull and interact with information in real time whilst allowing the wearer to maintain full use of their hands appears to be the major factor driving interest in the device.

The real time push, pulling and interactive capabilities provided by wearable technologies raises the issue of a digital strategy for meat processing facilities. At present, it is difficult to determine what the digital strategy is for meat processing facilities or for the meat industry in general. Furthermore, an investment in wearable technologies is an investment in people. The future roles of people within the industry and its alignment with the digital strategy is fundamental to any further investment in wearable technologies.

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