final report

Project Code:	P.PSH.0635
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Date published:	November 2012

PUBLISHED BY
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3D Modelling Trial

This is an MLA Donor Company funded project.

Meat & Livestock Australia and the MLA Donor Company acknowledge the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

This project will perform trials using 3D modeling software with the aim of creating example 3D models of meat cuts, primal and carcasses. The ability to produce these 3D models will support and assist with the development, adoption and commercialisation of automation within Red Meat processing by;

- enabling 3D models to be created and used for design of automation components
- enabling 3D models to be created for use in presentations, documentation, 3D layouts and simulations

The Ability to produce 3D models of meat cuts, primal and carcasses will provide useful industry information and tools for;

- possible use in industry training
- possible use for industry standards (eg Australian Meat to communicate detailed specifications and descriptions of red meat items/cuts)

Executive Summary

This project performed trials using 3D modeling software to create example 3D models of a lamb leg, and beef fore leg and hind leg. The ability to produce these and similar 3D models will support and assist with the development, adoption and commercialisation of automation within Red Meat processing by;

- enabling 3D models to be created and used for design of automation components
- enabling 3D models to be created for use in presentations, documentation, 3D layouts and simulations

The ability to produce 3D models of meat cuts, primal and carcasses will provide useful industry information and tools for;

- possible use in industry training
- possible use for industry standards (eg Australian Meat to communicate detailed specifications and descriptions of red meat items/cuts)

This project has resulted in the creation of the required models, and these models have been exported as both CAD models and using a web-based method satisfactorily

Both the beef fore leg and hind leg 3D models will be used by MAR for concept designs being considered for a Leg Bone Breaking system. MAR is currently performing self-funded trials for leg bone breaking automation development and working with an Australian Beef Processor to concept a suitable automated solution.

Contents

1 Background

This project will perform trials using 3D modeling software with the aim of creating example 3D models of meat cuts and primals, initially, to demonstrate capabilities and outline uses within the red meat industry for design, automation, training, presentation and more.

The ability to produce 3D models of meat cuts, primals and carcasses will;

- support and assist with the development, adoption and commercialisation of automation within Red Meat processing by;
  - enabling 3D models to be created and used for design of automation components
  - enabling 3D models to be created for use in presentations, documentation, 3D layouts and simulations
- provide useful industry information and tools for;
  - possible use in industry training
  - possible use for industry standards (e.g. Australian Meat to communicate detailed specifications and descriptions of red meat items/cuts)

The trials will model three sample meat pieces as a working example, namely lamb leg, beef fore leg and beef hind leg. Both the beef fore leg and hind leg 3D models will be used by MAR for concept designs being considered for a Leg Bone Breaking system. MAR is currently performing self-funded trials for leg bone breaking automation development and working with an Australian Beef Processor to concept a suitable automated solution.

2 Project Objectives

2.1 Project Objectives

The project will provide:

- preparation for trials including setup of equipment and software,
- perform 3D modelling trials - scan and collect images/data for sample pieces: lamb leg, beef fore leg, beef hind leg
- produce 3D CAD files and images of each piece
- produce concept automated cell 3D design model for beef leg breaking utilising 3D leg models as an example of use
- document trials outlining ease of modeling, and future practical uses for red meat processing and automation development

3 Methodology – Milestone 1

3.1 Outline of Methodology

The project objectives call for the production of textured 3D models of various meat cuts. The model generation process is divided into a data capture stage, followed by a model generation stage.

A series of various object tests were first undertaken to verify the process and identify any problems or special methods required for the process. An example of one of these tests is show in figure 2 in section 3.3.

The data capture stage requires a series of regular digital images of the chosen cut taken from various orientations that capture all the major details. The quality of these images directly affects the quality of the output model, so care was taken in the operation of the data capture setup.

These images are then fed into a software package where the backdrop is masked out and a model is generated. See section 3.3 for of this process.

3.2 Data Capture

The data capture setup consists of a tripod-mounted digital camera, a backdrop with lighting and a turntable with a printed reference mat. See figure 1 for a demonstration of the setup.

Once the setup is ready, a series of images are taken of a calibration grid to allow the software to account for optical distortion present in the camera lens.

The meat cut to be modelled is then mounted on the turntable, taking care that the reference mat beneath it is sufficiently visible to the camera.

A series of 25-50 images are taken, making sure to capture all required details of the cut, including a top-down view. To ensure that the model is an accurate 360° representation, the meat cut is then turned over and a second set of images are captured of the bottom.

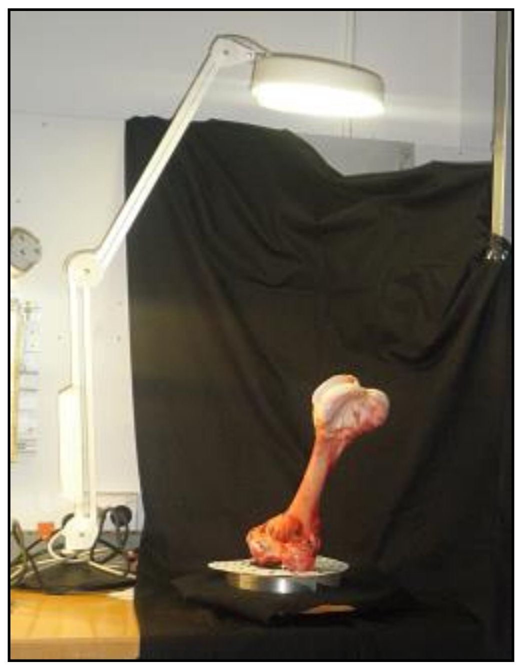

Figure 1: Data capture setup

The images are then ready to be loaded into the software for model generation and processing.

3.3 Model Generation

Model generation is carried out by 3D Software Modeller Pro (3DSOM), resulting in a textured 3D model that can be exported for use in any 3D software package.

The first step in this process is the calibration of the camera lens to account for focal length and distortion. The images taken of the calibration grid are fed into the 3DSOM calibration wizard, which calculates the distortion present and saves the lens correction to be later applied to the input images.

The first set of images of the meat cut is then loaded. The software detects the printed reference mat in the images and estimates the camera location from this, orienting the image as it goes.

The images need to have the backdrop masked out to allow the software to construct an accurate model of the meat cut. This process can be automated, but invariably requires significant human intervention to achieve accurate results. See the discussion in the next section for details.

A surface is generated from these masked images, creating a rough 3D model of the meat cut. This surface can be further optimised and edited by the operator, before a subdivision surface is fitted to it. This results in a compact form for the final model file. See figure 2 for an example of the surface created by this method.

The texture is then mapped onto the surface, with any imperfections removed by the operator. After this, the textured model is ready for use in 3D CAD software or can be exported to a web application for demonstrations or similar presentation.

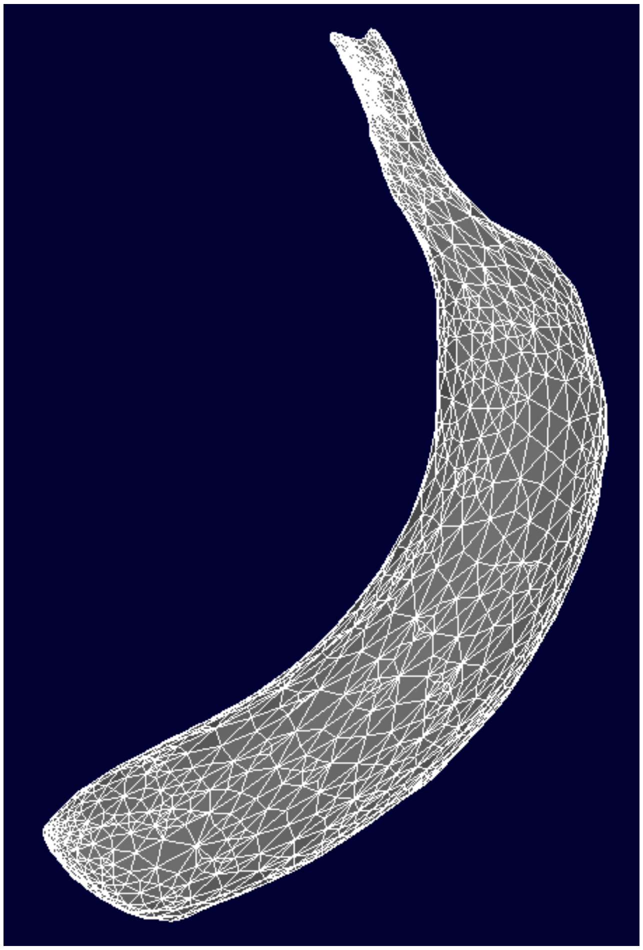

Figure 2: Example of surface production capability

4 Results – Milestone 2

4.1 Overview of Results

This project has resulted in the required models, namely the lamb leg, beef hind leg and beef fore leg. These models have been exported as both CAD models and a web-based method satisfactorily. Sections 4.2 to 4.4 demonstrate some output views of the trial models in the web-based presentation method, as well as a view of the surface and mesh generated by the 3DSOM software. Refer to section 6.1 for recommendations to improve the results further.

4.2 Lamb Leg Model

Figure 3: Typical output views of the textured lamb leg model

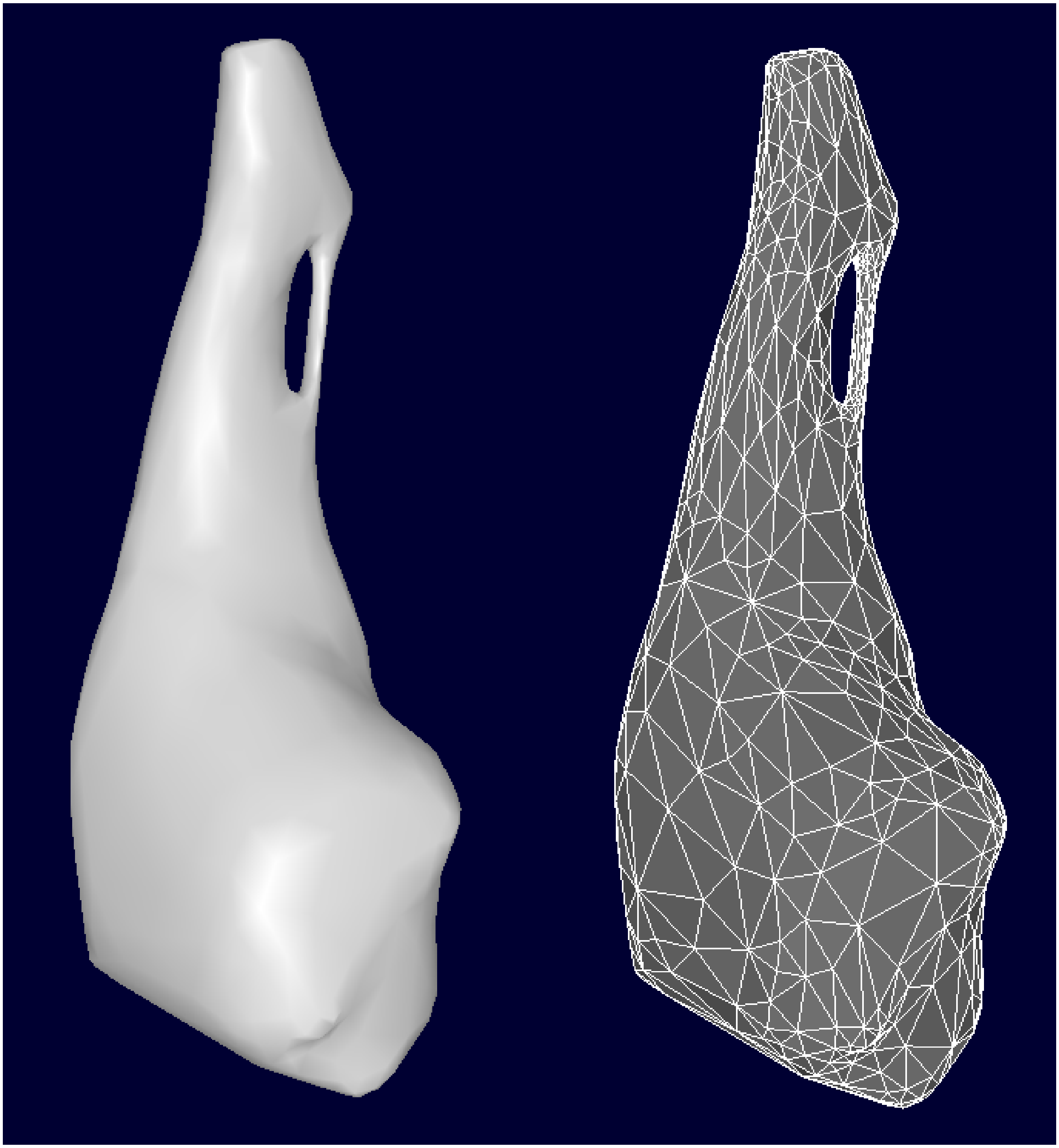

Figure 4: 3D surface (left) and mesh (right) of lamb leg

4.3 Beef Fore Leg Model

Figure 5: Typical output views of the textured beef fore leg model

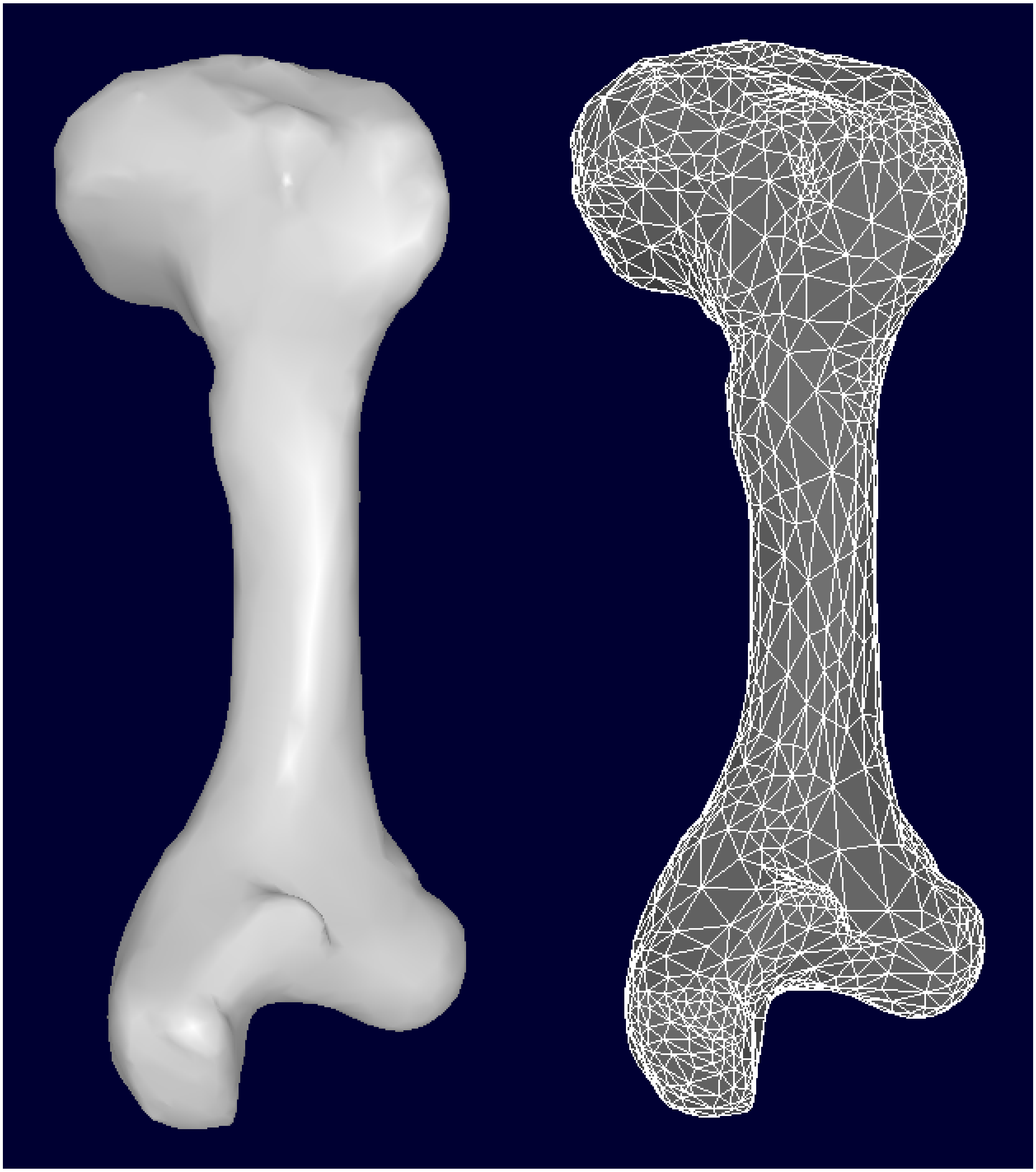

Figure 6: 3D surface (left) and mesh (right) of beef fore leg

4.4 Beef Hind Leg Model

Figure 7: Typical output views of the textured beef hind leg model

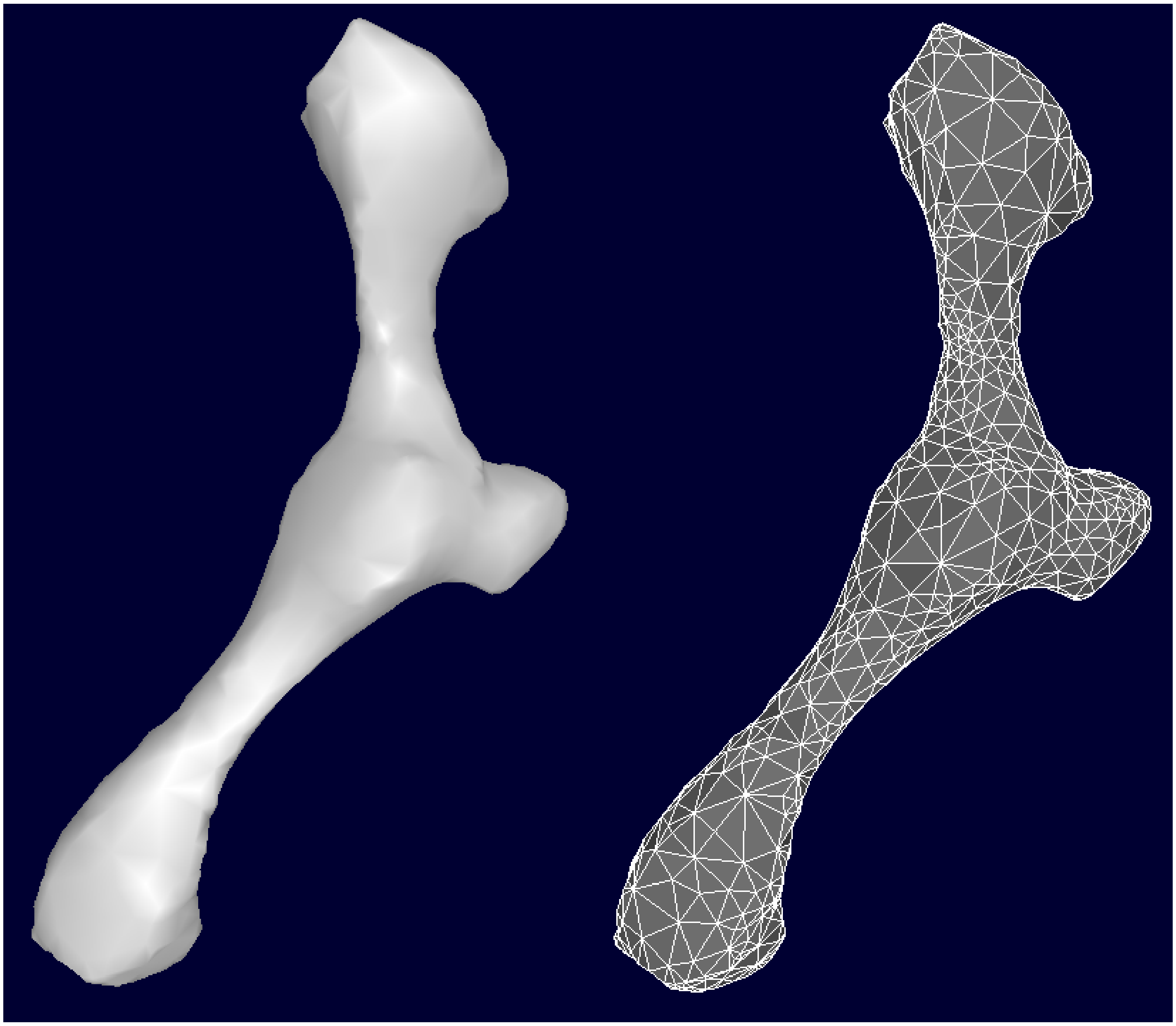

Figure 8: 3D surface (left) and mesh (right) of beef hind leg

4.5 Concept Automated Cell Design for beef leg breaking

The Ability to produce 3D models of meat cuts and primals supports development of automation for Red Meat processing by enabling 3D models to be created and used for design of automation.

The following is an example where the Beef Leg models obtained during this project enabled a more precise and explanatory design concept for Beef Leg Breaking to be generated.

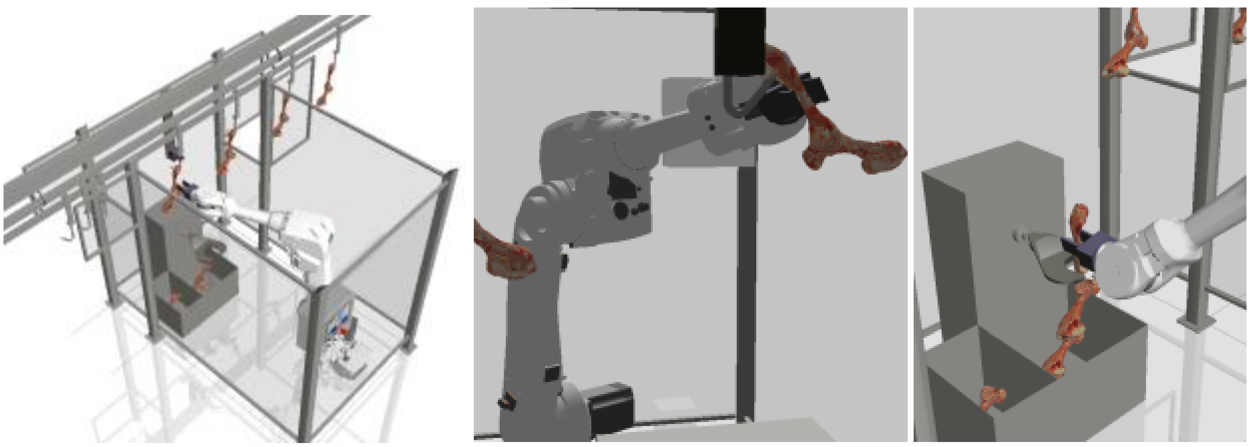

Figure 9: 3D Concept Automated Cell Design for beef leg breaking

The current manual beef leg breaking process requires one operator to perform the following operations:

- Trim Recovery of Hind Leg Bones
- Separation of Tibia (hind shank) and Femur at knee joint via knife
- Transfer of Femur Bone to Tub
- Removal of Tibia Bone from Hook
- Transfer of Tibia Bone to Tub
- Trim Recovery of Fore Leg Bones
- Separation of Fore Shank and Humerus (arm Bone) at joint via knife
- Transfer of Humerus Bone to Tub
- Removal of Fore Shank Bone from Hook
- Transfer of Fore Shank Bone to Tub

The design option shown above will be used and offered to a processor currently working with MAR to realise a possible option for an automated solution:

The concept generated would operate as follows:

1. Clamp and secure rail hook “variable for hind and fore”
2. Locate and define bone and hook style, location and orientation using 3D scanner
3. Mechanically clamp and secure bone attached to hook via the robotic gripper
4. Manipulate bone off the hook robotically.
5. Drive the bone to the fixed mounted hock cutter device locating to cut at desired location an angle analysed previously.
6. Operate Cutter, releasing lower cut bone to bin/chute “Humerus or Femur”
7. Drive top half of bone still attached to gripper “Fore shank or hind shank” to a second bin/chute and release.
8. Repeat Cycle.

The concept generated can also be viewed in a 3D PDF Concept Simulation generated for presentation and process demonstration purposes *“MAR-AutomatedBeefBoneBreakerSim.pdf”*

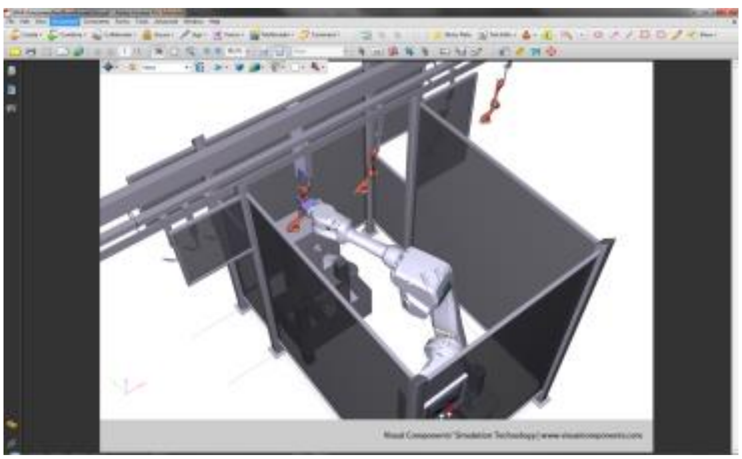

Figure 10: 3D PDF Concept Sim for Automated Cell Design for beef leg breaking

5 Success in Achieving Objectives – Milestone 3

5.1 Produced Models

The three trial models for this project were produced successfully, with the models able to be exported as both a 3D CAD file and a web-based, textured presentation model. The models have high-quality 3D surfaces and the textures are mapped neatly, allowing for the use of the models in training and demonstration in addition to use in production of automation machinery.

5.2 Produced Concept Design

The Ability to produce 3D models of meat cuts and primals supports development of automation for Red Meat processing by enabling 3D models to be created and used for design of automation. Within this project an example concept was used where the Beef Leg models obtained enabled a precise and explanatory design concept for Beef Leg Breaking to be generated. The design option will be used and offered to a processor currently working with MAR to realise a possible option for an automated solution.

5.3 Process Success

The process utilised to achieve this outcome was successful, with satisfactory results produced. The speed and quality of this process can be significantly accelerated beyond what was achieved in this trial with the adoption of the recommendations presented in the next section.

6 Conclusion and Recommendations

6.1 Recommendations

The project achieved success with the production of the three textured 3D models. The main impediment to greater speed in the production of the models is the task of masking the backdrop from the object to be modelled. At the moment, the process requires significant manual intervention to ensure neat and accurate masking. As a large number of images are required to be masked, in the order of 25-50 depending upon model complexity, this task slows the throughput of the process markedly.

The changes to the process recommended to improve speed include changes to the environment and image capture tools. The construction of a dedicated image capture cell with a green-screen backdrop and appropriate lighting would allow the software package to more autonomously isolate the object. The correct arrangement of lighting on both the object and backdrop would also help this effort, with the added benefit of producing consistent lighting conditions between models.

In addition to the image capture cell, a high-resolution digital camera with a fixed mount on the cell would allow for better quality textures on the final model and faster image capture times. Consistent lighting would also remove the necessity to set camera parameters each time a new model is required.

6.2 Further research and use of technology strategy

The project achieved success with the production of the three textured 3D models with relative ease. MAR will explore the possibility with MLA and other industry representative to collect images and data for automation and industry uses. As an example it may be beneficial for the industry to model all Sheepmeat and Beef cuts, primals and carcass conditions. This would provide an ideal platform for design, training, specification and red meat marketing purposes.

The Ability to produce 3D models of meat cuts, primal and carcasses will support and assist with the development, adoption and commercialisation of automation within Red Meat processing by;

- enabling 3D models to be created and used for design of automation components
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The Ability to produce 3D models of meat cuts, primal and carcasses will provide useful industry information and tools for;

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- possible use for industry standards (eg Australian Meat to communicate detailed specifications and descriptions of red meat items/cuts)

6.3 Conclusion

This project has demonstrated the successful capture of amorphous real-world objects, namely selected meat cuts, into a 3D CAD environment accurately and efficiently. It also demonstrates the feasibility of making textured 3D models available for meat industry demonstration and presentation needs.

Acceptance of the recommendations of this report will allow for the production of textured 3D models of all meat cuts in a timely manner. This production will benefit both MAR in its development of automation solutions for the meat industry and MLA in demonstration and training purposes.