The goal of this research is to investigate and develop methods to understand and predict the behaviour of animals from an estimation of their motion and environmental context. These methods are intended for use on a mobile robotic platform in order to interact with animals.
The research will take place within the Australian Centre for Field Robotics at the University of Sydney, as part of on ongoing project with Meat and Livestock Australia. This project is aiming to establish methods to determine objective measures of animal welfare and physical condition using computer vision techniques within the agriculture industry.
This is an important challenge that is two fold in it's aims: allowing the estimation of the current state of the animal with regards to it's behaviour, relevant to activities such as health and welfare monitoring, injury detection and stress identification; and allowing for better interaction between a robotic system and an animal or person through the prediction of behaviours that require an intervention or action from the system, in activities such as herding, handling, and examining animals in order to determine their physical condition.

Most livestock animals are less expressive of pain than humans, as such any behavioural indicators of pain that livestock do express are subtle and hard to identify in practice. An animal experiencing discomfort or stress is more likely to have compromised welfare, which can directly affect their productivity.
By applying computer vision systems to track the pose of animals through a series of images and estimating their motion, it may be possible to identify behavioural indicators of discomfort in a similar manner to activity recognition systems currently in use. This would involve using the time series estimation of the animal's pose as an input feature into a classification system such as a recurrent neural network. This network would learn its own identifying features within the motion, rather than relying on hand picked features as used in techniques such as gait analysis, and so would be more likely to pick up on subtle cues exhibited by animals regarding their behaviour. By limiting the input feature to a series of body joint positions in 2D, rather than a complete camera image, it can also be possible to obtain highly accurate results in classifying behaviour from a limited dataset, allowing for easier application in practice.

Depending on the dataset used, applications could include identification of lameness, sickness or specific stress levels using a supervised learning approach, or of any abnormal behaviour in livestock using an unsupervised approach. Part of this research would be a comparison of the effectiveness of using unsupervised learning approaches for outlier detection against classification using a labelled ground truth.

A better understanding of the relationship between body motion and behaviour will also help enable robotic systems to interact with humans and animals in future. The methods described above to estimate current behaviour of an animal can also be extended to predict the likely next behaviour of an animal, allowing for a better prediction of motion during interactions with animals. An example of this would be the identification that an animal is experiencing high levels of stress during herding and understanding how this relates to the probability that this animal may balk towards the observer. The ability to predict this type of behaviour in animals could also enable robotic systems to operate in such a way that undesirable states, such as high stress levels can be minimised in the animals it interacts with.

This work closely relates to current research being done with regards to crowd motion analysis, in which the behaviour of various members of the crowd, or agents, is estimated at future time steps based on the motion of all other agents. By including the current and predicted behaviour of each agent as a state variable, and by including the observer itself as an agent, it could be possible to model the herding process as a Markov decision process and predict how the movement of the observer is likely to affect the movement of all other members of the herd or crowd. This could be extended into a tree search approach to find the movement which is most likely to achieve some next optimal state of the entire herd or crowd, feeding into the decision making process of the robotic vehicle during the task of herding, or otherwise interacting with animals.

This research would also help facilitate ongoing research within the ACFR on a project funded by the MLA, aimed at examining animals in order to determine their current physical condition. By identifying the current pose of an animal it is possible to fit an initial class-generic model to the observation, to allow faster reconstruction of the animal 3D model and better estimation in situations in which complete observations are not possible.

The recreation of a 3D model of an animal would allow for objective measurements regarding animal size and body state to be gathered in the field and compared to previous measurements of the same animal, tracking its welfare and growth over time.

Data necessary for the above research areas is intended to be collected as part of the MLADC1 and MLADC2 projects across a number of planned excursions to feed lots and farms, working with the SwagBot team in ACFR for implementation and testing.