Automated measurements of emotions in pigs

We explored the potential of thermal imaging and artificial intelligence (**AI**) in animal emotion research. Thermal cameras play a vital role in obtaining and collecting large volumes of multidimensional data, and AI has the capabilities of processing and extracting valuable information from these data. The amount of data collected using thermal imaging is huge, and automation techniques are therefore crucial to find a meaningful correlation between animal emotional state and changes in body temperature.

This research developed a pipeline to automatically extract the maximum temperature from a selected region of interest (**RoI**) from thermographic images collected in pigs. The base of the ear of pigs was chosen as RoI in this study, as it is proposed as an important area in emotion research (Boileau et al., 2019; Lu et al., 2018). This RoI can be observed well from a top view which was, thus, how the thermal camera was installed. The developed pipeline consists of three stages. The first one checks whether the RoI is completely visible to extract the thermal temperature. If so, the second stage detects and segments both ROIs (left and right ear base) from the frame. In the last stage, the maximum temperature is extracted from the segmented RoIs, which is subsequently saved in an external file together with frame number.

The thermal imaging videos were captured during a frustration challenge test, which was part of a larger experiment to study resilience in pigs (see for more details Luo et al., 2022). The experiment was conducted at Carus, the animal research facility of Wageningen University & Research, Wageningen, the Netherlands. A total of 373 female pigs (TN70 x Tempo) were tested in the frustration challenge. For this challenge, each pig was taken out from its home pen and moved to a small pen (1.2x0.6mtr) in a test room for 10 minutes. Here, the isolated animal was able to see and hear other pigs exploring and playing freely in a "play arena". The inability to join the playing pigs may have induced a feeling (emotion) of frustration. A FLIR T1020 thermal imaging camera was mounted on a tripod with a distance of about 1mtr between the pig's head and the camera (for more details, see [1]). A total of 373 thermal imaging videos were recorded during the test.

Camera's

Thermal camera

A FLIR T1020 thermal imaging camera was mounted on a tripod with a distance about 1meter between the pig's head and the camera. The resolution of the camera was 768, 1024 pixels, and had a 40 mm focal length lens with an accuracy of 0.02 reading at 25°C and a thermal sensitivity range of -40 to 2000 °C. More information about the camera specification is at this link.

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Emotional state in pigs

The raw data were thermal videos with an extension 'csq'. The FLIR Research programme was used to pre-process thermal videos and convert thermal frames into both a jpg format and a csv format; the jpg images were used to train the models and the csv format to extract thermal information. The figure below (Figure 1) shows the complete process of extracting temperatures.

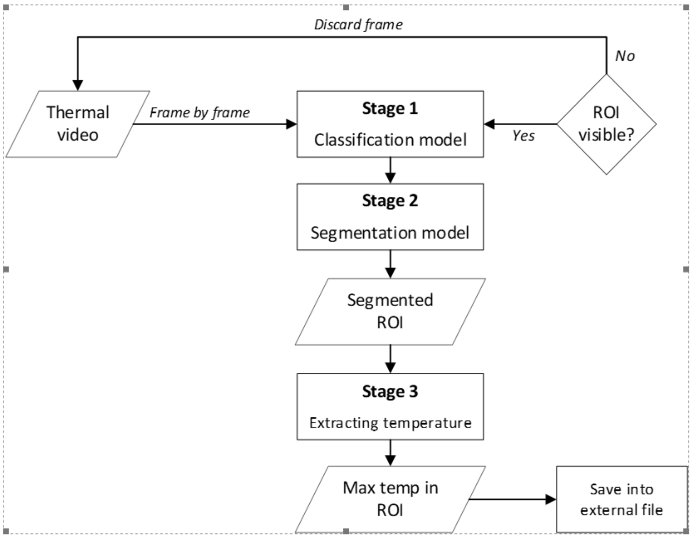

Figure 1. Flow chart of the complete model

For each frame in the sequence of a thermal video, the thermal frame was converted to a jpg image format and resized to an image size of 320 x 320. The classification model examined the visibility of the ROI. If the condition was met, the segmentation model segmented the ROI of both sides and forwarded it to the final stage of the model to extract the temperature. The maximum temperatures of both sides with their coordinates were saved as records in a csv file along with the frame number. If the ROI was not completely visible in the frame, the frame was discarded, and its record was saved as a missing record. Then, the next frame went through the same process. At the end of the thermal video, the file was saved externally on a hard drive to be analysed for further research. Each thermal footage had a duration over 10 min. After processing by the model, more than 19,000 records were saved per video. Table 1 below shows an example of extracted and saved temperatures.

Table 1. Example of extracted and saved temperatures

Frame	**Left Temp**	**Right Temp**	**L_pos**	**R_pos**
0	39.83	39.48	(652, 667)	(724, 614)
1	39.78	39.45	(631, 673)	(718, 619)
2	39.56	39.38	(623, 679)	(709, 636)
3	39.53	39.24	(615, 690)	(694, 649)
4	39.55	39.20	(599, 698)	(682, 660)
5	39.39	39.20	(576, 712)	(665, 674)

Locations of scripts

The three-staged pipeline has three directories, where each directory tackles a one stage. The Figure 2 below shows the organisation of the scripts and their functions.

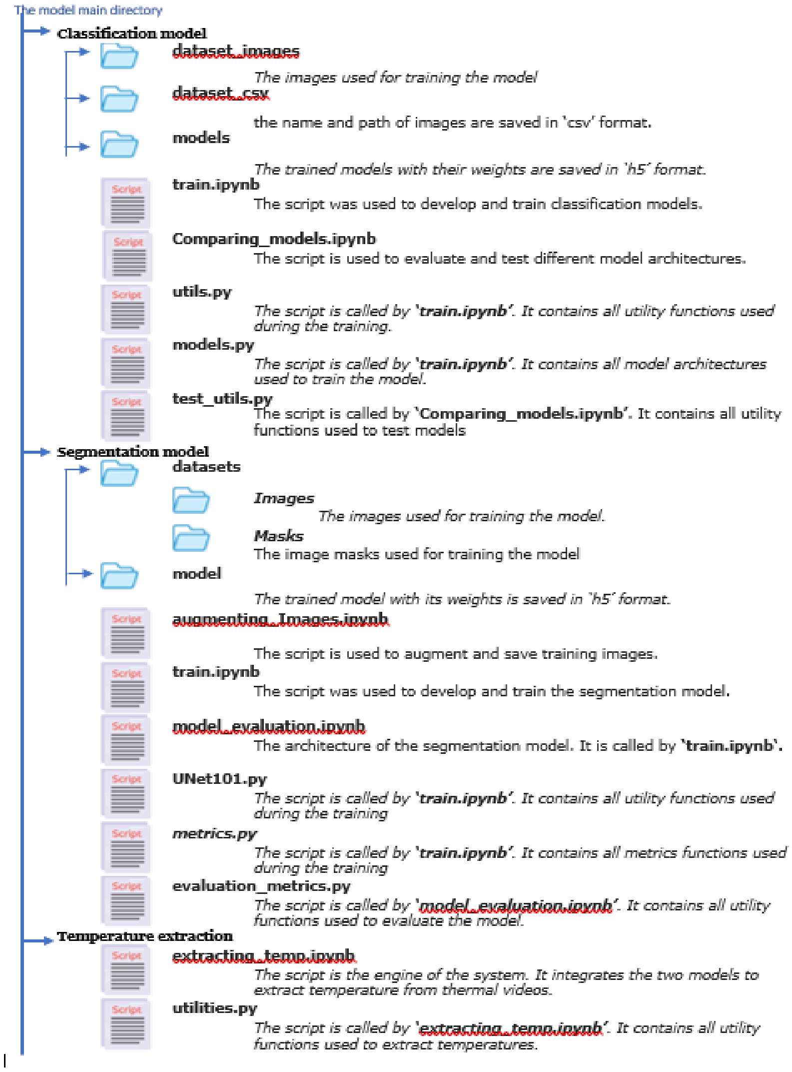

Figure 2. Scheme of organisation of the scripts and their functions

Lesson learned

- Integrating thermal imaging and AI has great potentials in animal research, have not yet been explored. Thermal imaging is a contactless and non-invasive technique to remotely observe the temperature distribution patterns on the surface of the observed objects. They are able to obtain and collect a large amount of data without stressing the observed animal, and AI has the capability of processing and extracting valuable information from these data. The amount of data collected using thermal imaging is huge, and automation techniques are therefore crucial to find a meaningful correlation between animal emotion and changes in temperature.

- Animals can be monitored remotely without human interventions over long period of time using deep learning models. This may help in improving animal welfare.
- The experiment setup for recording animals for designing a deep learning model should be checked by the model developer to avoid recording useless data. It is better to do a small experiment to check the quality of recorded data before carrying out the whole experiment. The scope and the location of the camera should be examined by the developer at the beginning. There were some data losses because of either the pigs were able to move out of the scope of the camera or the pen boundaries hiding the head of the animal.
- The camera was set at the side of the pen over a tripod higher than the observed pig. When the pig turns to the other side of the pen, this is out of the camera scope. Other setups of camera positions could be tested to examine if the camera scope has better coverage.
- For future research, other animal body parts can be studied using the same methodology.
- Although the pig was able to move freely in this study, it was confined alone in a small pen as a negative stimulus. The model's performance therefore still needs to be examined in conditions where pigs have close interactions with each other, which is the normal situation in a farm. Some modifications may be needed to accommodate the new filming situation, which can be investigated in future research.

List of people involved and their role

Name	Email address	Role in project
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Output

Scientific output:

Bekhit, R., I. Reimert. 2024. "A complete pipeline to extract temperature from thermal images of pigs" (in progress)