Analysis of Dairy Cow Rumen Fill using 3D-Image Data from iToF-Sensors

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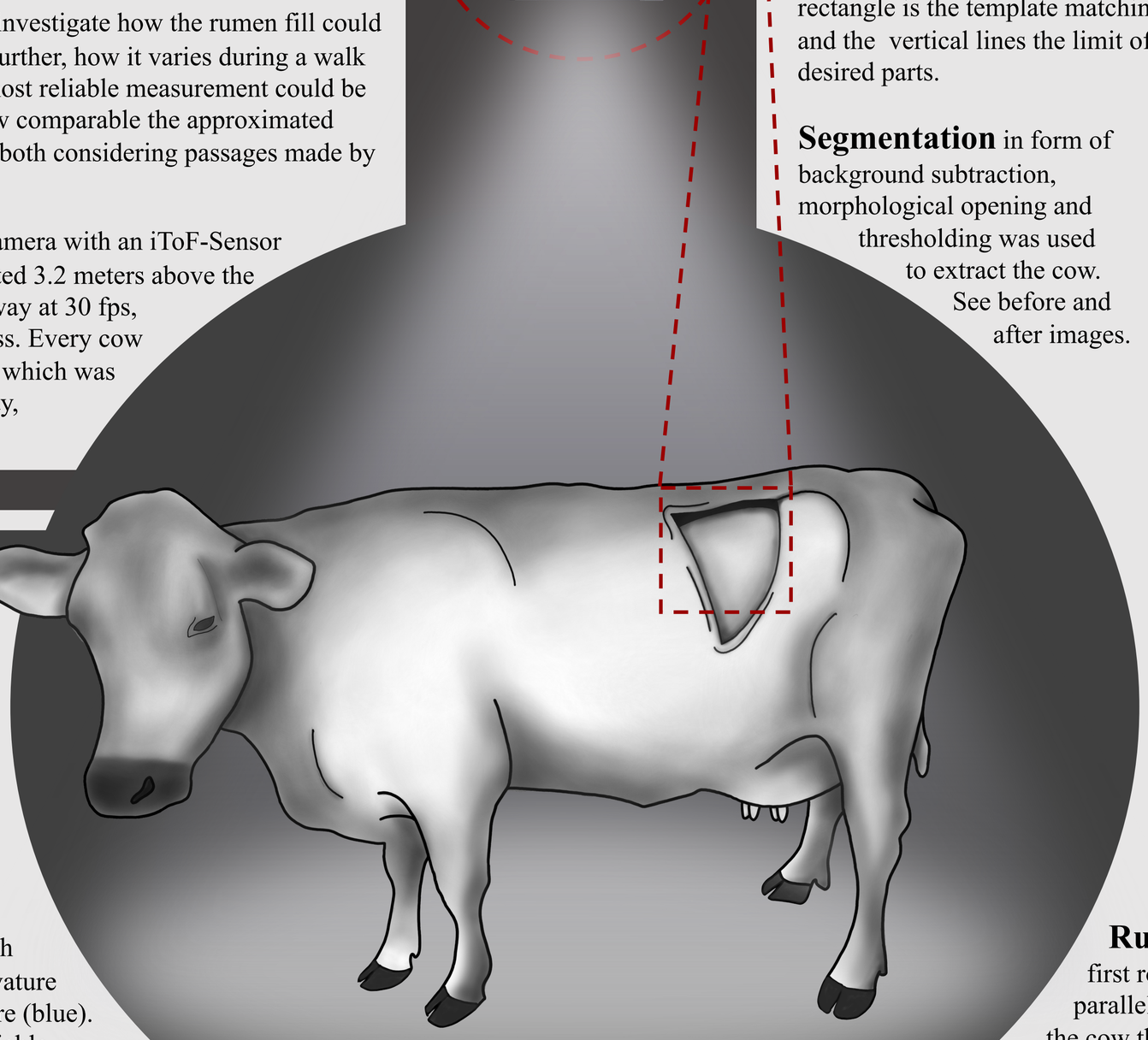
1 Introduction

Viwa (VisionWelfare assessment) is a collaboration between Swedish University of Agricultural Sciences in Uppsala, Sony, RISE, Växa Sverige and Högskolan Dalarna. The aim is to develop vision-based tools for assessing defined welfare measures in dairy cows. This is an example of precision livestock farming (PLF), which is automated monitoring of animals with the aim to improve welfare.

The rumen is the cow's largest stomach. Depending on food and water intake the rumen fill varies, which can be detected by inspection of the paralumbar fossa (the red dashed rectangle).

The aim of this project was to investigate how the rumen fill could be approximated using 3D data. Further, how it varies during a walk cycle, and in what sequence the most reliable measurement could be taken. It was also investigated how comparable the approximated rumen fill was between passages, both considering passages made by one and several cows.

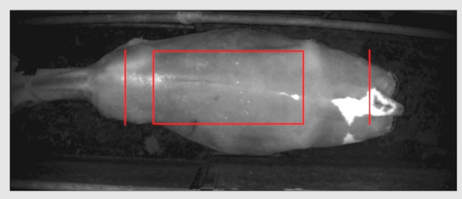
The setup consisted of a 3D camera with an iToF-Sensor (made by Sony) which was mounted 3.2 meters above the ground filming a narrow passageway at 30 fps, where one cow at a time could pass. Every cow has an RFID tag in their right ear, which was read when entering the passageway, starting the recording.



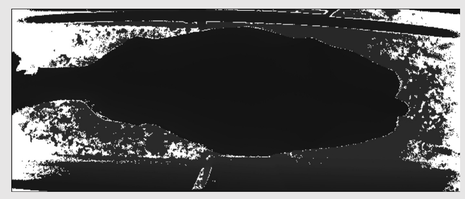
2 Method

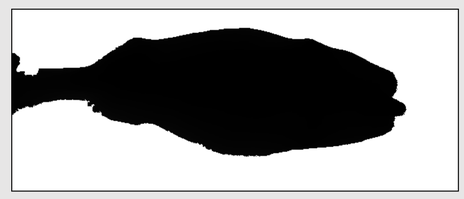
Classification of 480 cow passages was performed, manually, into three classes. These classes were given a score of 1, 3 or 5, where higher scores represent higher rumen fill. Some cows were studied more thorough with 5-point scoring system, to give a more detailed analysis.

Template matching (cross correlation) using the z-component of the 3D data was used to determine if the desired parts of the cow was in the frame. The rectangle is the template matching and the vertical lines the limit of desired parts.

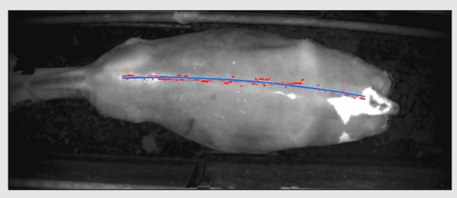


Segmentation in form of background subtraction, morphological opening and thresholding was used to extract the cow. See before and after images.

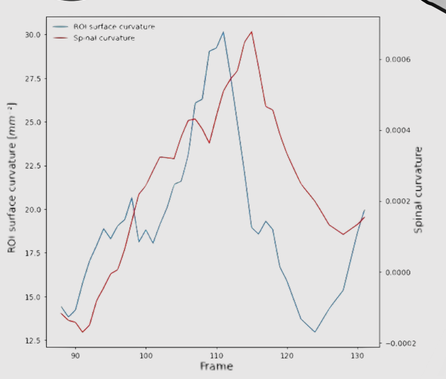




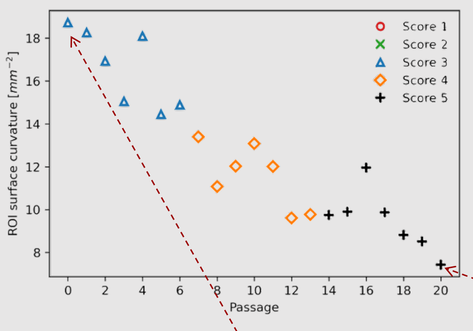
Spine localization was performed by inspecting the highest points in each column, see red dots. A second order polynomial was approximated using least square method, see blue line.



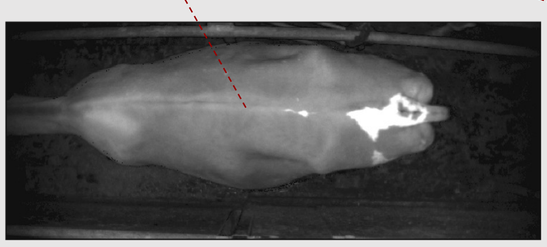
3 Results

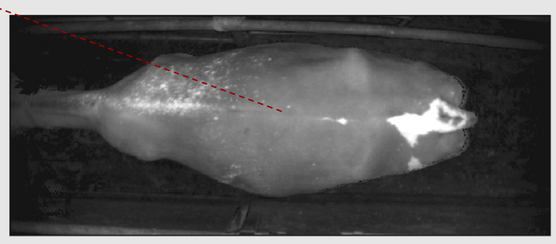


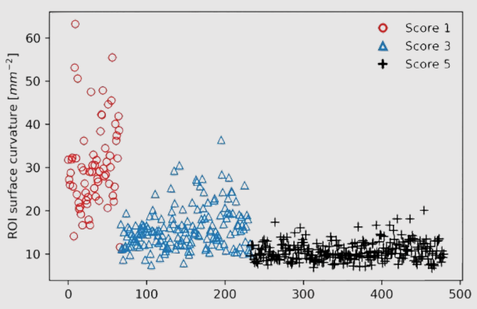
The walk cycle showed a high correlation between the spine curvature (red) and the ROI surface curvature (blue). It was concluded that the most reliable measurements were obtained when the spine was straight as can be seen in the figure above which is when spinal curvature is close to zero



Individual cows were analyzed. In the plot to the left each point represents one passage, all made by the same cow. Investigation of eight cows showed a high correlation of the manual ordering of the passages and the approximation of the rumen fill. Further, the classes could be moderately separated.

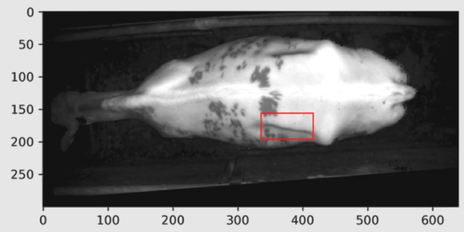


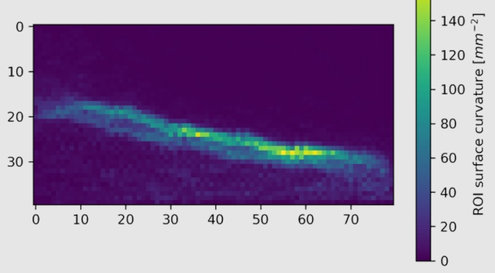




All passages were analyzed based on the classification using 3 scores. The result can be seen in the plot. The classes were separated by at least 75 %. Further, analyzing the spread of the passages made by the same cow within a certain class showed no clear clusters. Both results indicate that it is possible that the method can be used to compare rumen fill between different cows.

Rumen localization was performed by first rotating the image such that the spine was parallel to the x-axis. Then thresholding parts of the cow that differed more than 0.1 m in height compared to the spine. This left the hook bones as the widest part of the cow. The rumen was localized based on the coordinates of the left hook bone. The found region of interest (ROI) is marked with a red rectangle.





Surface curvature calculation of the ROI was performed for each point in the point cloud by fitting a plane using the least square method with its eight neighbouring points. The variance of the absolute distances from the points to the plane was used as the approximation of the surface curvature.

4 Conclusion

The localization process of the rumen was robust with few unsuccessful localizations. The developed ROI surface curvature method worked well approximating rumen fill of passages made by individual cows. Furthermore, considering all passages, the classes were separated with at least 75%. The uncertainties in the results depends mainly on insufficient classification.

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