Automated Infrared Based Health Monitoring System for Veterinary Application

T. Wirthgen\textsuperscript{a}, S. Zipser\textsuperscript{a}, U. Franze\textsuperscript{b}, S. Geidel\textsuperscript{b}, M. Zimmerhackl\textsuperscript{c, a}\textsuperscript{*}

\textsuperscript{a} Fraunhofer Institute for Transportation and Infrastructure System, 01069 Dresden, Germany
\textsuperscript{b} HTW Dresden (University of applied Science), 01069 Dresden, Germany
\textsuperscript{c} DIAS Infrared GmbH, 01217 Dresden, Germany

Abstract

Within the interdisciplinary R&D project VIONA a novel hard- and software system was developed to investigate the potential of an automatic infrared (IR) based health monitoring. The system developments and the comprehensive practical tests were focussed on the veterinary application dairy cows. Special attention was paid to the rough practical conditions in dairy farms. The system enables a complete automation of the workflow from IR image acquisition to alarm list generation for the veterinary personal. The development contains the three main issues: precise IR temperature measurement under varying ambient conditions, image processing to extract accurate temperature features of anatomic structures automatically and statistical diagnosis algorithms based on individual time series of temperature features.

The studies on hundreds of dairy cows showed that with advanced IR technology and data processing the IR based approach has a significant potential to detect common inflammation diseases.

© 2011 Published by Elsevier Ltd. Open access under CC BY-NC-ND license.

Keywords: health monitoring, infrared temperature measurement, automatic object detection

1. Motivation and Introduction

The trends to higher efficiency and automation in livestock farming (feeding, milking, etc.) supports the development of automatic systems. The task of automatic health monitoring is not satisfactorily solved yet. In case of dairy cows it is known, that the most important diseases are inflammation diseases of udder

* Tom Wirthgen. Tel.: +49-351-4640-649; fax: +49-351-4640-803.
E-mail address: tom.wirthgen@ivi.fraunhofer.de.
and claws. These diseases are associated with surface temperature changes that can be monitored with IR thermography (IRT) principally. Although human medicine has well defined standards [1], other methods have higher acceptance. In contrast for veterinary applications the IRT is accepted and advantageously applicable [2]. Additionally in most cases no alternative method or no method capable for screening of whole herds (regular daily monitoring) exists.

Within the R&D project VIONA a platform for an automatic health monitoring was developed. The system was optimized for dairy cows milking at a rotary parlour (Fig. 1 and Fig. 2) but is not limited to that case, e.g. other species are possible.

![Fig. 1. Image of a rotary parlour](image1)

![Fig. 2. Measuring situation of VIONA system](image2)

In contrast to human medicine veterinary applications have some challenges as varying ambient conditions (temperature, humidity, etc.), rough conditions (dirt, high pressure cleaning) and moving animals (no briefing) faced by the VIONA project.

This paper gives an overview of the main issues of the VIONA system:
- a precise IR temperature measurement under varying ambient conditions,
- an image processing to extract accurate temperature features of anatomic structures automatically and
- statistical diagnosis algorithms based on individual time series of temperature features.
2. Precise IR temperature measurement

The IR based measuring of absolute temperature values is influenced by many disturbing effects as the emissivity of the measuring object, background radiation and drift due to camera self-heating. Hence an analysis of temperature measurement uncertainty was done. The common veterinary IRT using a state of the art calibrated IR camera and considering of background radiation leads to an absolute temperature uncertainty of about ± 2.2 K [3]. Compared to typical diagnostically relevant temperature differences of about 0.5-1.5 K this uncertainty is very high. So for the analysis of comparable time series a reduction of the temperature uncertainty is necessary. The use of a new developed robust reference body in combination with a high resolution calibrated IR camera and an adapted measuring configuration provide a temperature measurement uncertainty of below ± 0.47 K [3].

3. Automatic image processing

The first task of automatic image processing is the segmentation of interesting anatomic structures as the udder or the claws. For each of these image regions several IR features for example the mean and maximum temperature are derived from the temperature image in a second step.

For the automatic segmentation the Active-Shape-Model is a very potent approach, due to the flexible model based approach it is adequate to handle animal individual differences and animal movement. The search strategy was adapted to IR image characteristics thus the modified ASM gives high detection rate and quality [4]. The anatomic related regions are defined based on the fitted ASM (Fig. 3).

![Fig. 3. IR image including the automatically fitted Active-Shape-Model (green) and the anatomic related regions (red: left and right udder, yellow: left and right claw) resulting from the automatic image processing.](image)

Comparative analyses show good correlation between the IR features manually and automatically segmented images.

The developed image processing allows the analysis of image sequences and a high quantity of images. E.g. during the last measuring campaign 480 animals are monitored over 100 days and more than 1.5 million IR images are processed automatically.
4. Diagnosis algorithms

The diagnosis algorithms finally select diseased animals based on the measured IR features. Therefore the daily IR features, the measured ambient conditions and selected parameters from the rotary parlour are recorded. In combination with extensive manual reference examinations for the health state of the monitored animals this allows the development of diagnosis algorithms.

For the derived IR features the robustness against disturbing influences and the diagnostic merit are systematically evaluated and capable features are selected. The IR features (esp. the mean temperature of a region) have to be corrected to the ambient temperature [5]. First results for the diagnosis algorithms show that the use of animal specific time series is advantageous to get high finding rates and that the detection of diseased animals is possible [5]. The investigations in that field are ongoing.

5. Summary and Outlook

The developed IR measuring system VIONA provides the combination of precise IR measuring and automatic image processing by a significant reduction of IR temperature uncertainty. The automatic object detection based on a modified Active-Shape-Approach gives high quality segmentation results and offers automatic extraction of animal individual time series of IR features. The diagnosis algorithms show promising results for the early detection of inflammatory claw and udder diseases and were currently optimised.

With the VIONA system a new research platform is available for veterinary health monitoring studies.

Acknowledgements

This investigations are done within the scope of the VIONA project financed by the German Federal Ministry of Education and Research (BMBF, ID 03WK04B). The authors are grateful to the industry partners of the project DIAS Infrared, Ralle Landmaschinen, and Yoo GmbH as well as the hosting farms Methauer Agro AG and Großdrebnitzer Agrarbetriebsgesellschaft mbH.

References