RZESZOW UNIVERSITY OF TECHNOLOGY Rzeszów, 2026

Faculty of Mechanical Engineering and Aeronautics

Department of Applied Mechanics and Robotics

DOCTORAL DISSERTATION ABSTRACT

Title: Development and Implementation of a Hybrid Optical Inspection Method for Heat-Sealed Packages

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Key words: hybrid imaging, quality inspection, image fusion, machine learning, deep learning, packaging inspection

The dissertation presents a hybrid vision inspection method for heat-sealed packages. The research aimed to develop a system that uses image fusion from two vision channels. Leveraging the properties of selected optical radiation bands facilitated the acquisition of complementary data regarding defects arising after the sealing process.

The first section of this work provides a comprehensive literature review and state-of-the-art analysis within the investigated research domain. Next, a conceptual framework for the hybrid inspection system has been developed and validated through digital simulation. A laboratory model of the system was then constructed, enabling experimental evaluation under simulated operational conditions. The core contribution of this study involves the development of a novel image fusion method that integrates data from a visible-light camera and a thermal imaging camera. The synthesized images generated by the implemented algorithm were subsequently used to train a deep neural network model, enabling robust defect detection and classification.

In the next phase, the inspection system was integrated into a robotic research workstation. The acquired process data enabled the deployment of machine learning methods to predict the quality of the heat-sealed packages.

The final chapter outlines the development of a prototype device compliant with food industry standards. The effectiveness of the proposed solution was validated through factory acceptance testing conducted in collaboration with quality control personnel from the end-user organization.