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Multitask learning approach for fruit ripeness prediction using a dual band thermal camera

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Abstract

Multi-Task Learning allows to comprehend multiple tasks based on a single neural architecture by making the assumption that the tasks are related. We propose a multi-head architecture that allows to classify melon fruits into ripeness classes by taking images based on dual band mid- and longwave infrared (IR) thermography. To study the ripening labels based on sugar content, firmness and aroma are studied. We are able to show that multi-task learning delivers superior results for multimodal and multi-label situation when different tasks exhibit a positive transfer.

1. Introduction

The surpass of performance of deep learning methods in comparison to traditional machine learning techniques has led to a highly competitive field of research with competitions in outmatching state of the art benchmarks. These competitions have largely been dominated by ensemble methods where multiple neural networks are trained simultaneously for raising performance based on learning a single task. Multi-Task Learning (MTL) leverages for better performance by making the assumption of a positive knowledge transfer among tasks. This predominately can be ascribed by the introduction of inductive bias that leads to a decrease in overfitting caused by the positive relation between tasks. This task relatedness makes the assumption that a common prior is shared or that the trained parameters by all the tasks are characterized by a small distance. To study the impact of sugar content and aroma, various distinct classification tasks will be learned under a single architecture, following the hard parameter sharing approach. The hidden layers will be shared between classification tasks, while the last fully connected layers will be task specific. A great advantage of this approach is that it reduces the risk of overfitting and shows to be convenient for when facing multimodal problems. By learning several tasks simultaneously, the model tends to find a common representation for both tasks and, thus, avoids the risk of overfitting.

2. Materials and methods

To study the impact of biochemical features 40 different melon fruits were test, consisting of 10 watermelons and 30 Galia melons. To inspect the formation of the sugar content, aroma formation and stiffness variations a tasting panel was organized. The panel was executed based on a person remaining the same diet over length of the panel. During this time the fruit was stored in ambient conditions. During this period external changes such as the presence of bruises and the emergence of moldy regions where studied.

The probes were studied using pulse thermography using a Thermosensorik QWIP Dualband which is working in the wavelengths of 4.4-5.2 µm for the mid wave (MW) and the 7.8-8.8 µm in the long wave (LW) infrared bands. Active thermography was applied using a circular halogen lamp for which both camera and energy source was placed frontal to the probe. The first frame after application of the FFT for both channels can be viewed for different ripening stages in Figure 1 which was processed by using histogram equalization.

3. Conclusion

With our study we are able to show that multitask learning shows to be suitable when studying the fruit ripening using multiple modalities when positive knowledge transfer among tasks takes place. For this, neural architectural search was applied delivering superior results.

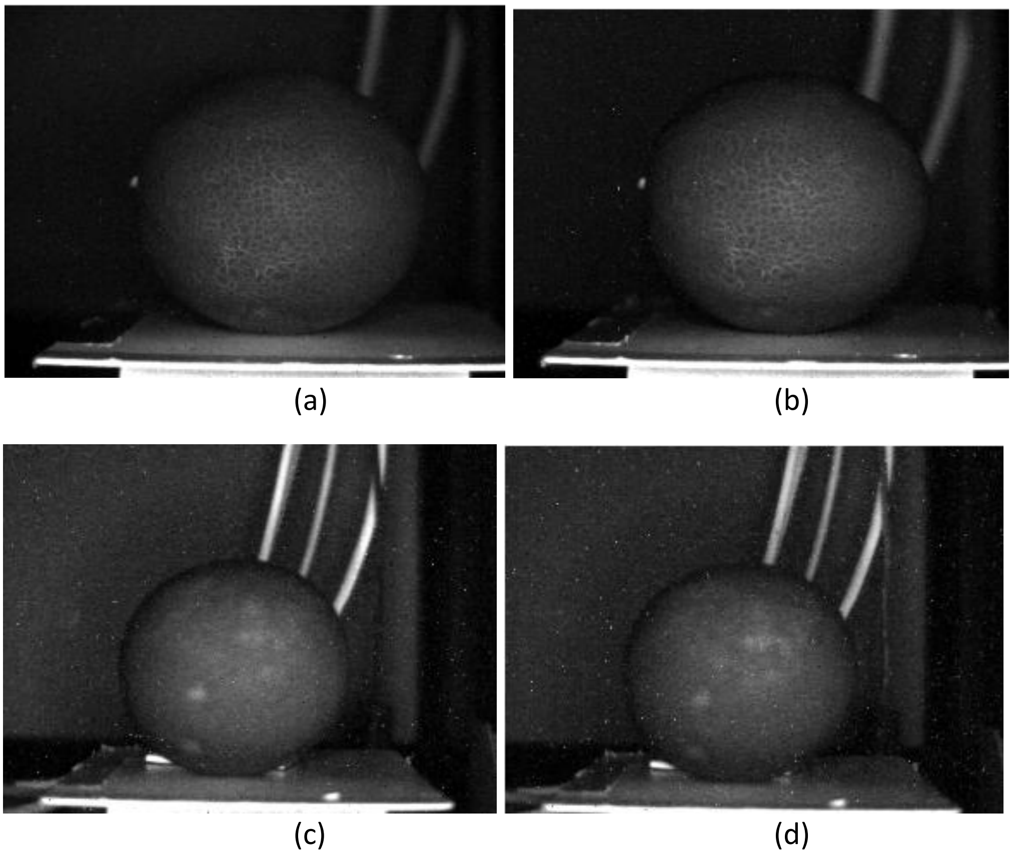

Figure 1. *First FFT frame in the infrared (a), (c) mid- and (b), (d) long wavelength (a), (b) before and (c), (d) after ripening*