

Estimating the cracking risk in pomegranate fruits using RGB and Thermal sensing

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Background & Significance

Pomegranate cultivation, production, and export have significantly increased over recent decades. However, a major issue affecting pomegranate growers is the cracking of mature fruits, which can lead to economic losses of up to 65% (Singh, Shukla, & Meghwal, 2020). This problem is widespread across all growing regions and varieties, making it a global concern that needs effective solutions.

Pomegranate cracking is a complex issue. The fruit's peel consists of an inner spongy tissue and an outer smooth skin layer, cracking starts as tiny cracks in the outer layer and deepens until the inner seeds are exposed (Chang, Zhang, & Keller, 2019). Factors like rain, excessive irrigation, and high temperatures during the fruit's growth phase can contribute to cracking (Joshi, Schmilovitch, & Ginzberg, 2021). Additionally, there can be a delay between the causes of cracking and its appearance, making it difficult to address (Joshi, Schmilovitch, & Ginzberg, 2021).

Predicting the risk of cracking is crucial for implementing preventive measures and improving yield management. By identifying early indicators of cracking, farmers can adjust irrigation practices and other management strategies to mitigate potential losses.

Research objectives

The research aims to estimate the risk of cracking in pomegranates using ground multimodal sensing technologies. Early detection of cracking can help to prevent it.

The main objectives are to:

- Acquire multimodal images (RGB and thermal imaging) of pomegranates throughout the growing season, under various irrigation treatments.

- Apply image pre-processing techniques to identify features.
- Develop a predictive AI model using DL/ML to predict the likelihood of pomegranates cracking to help prevent it.

Research Gap & Motivation

Even though pomegranate cracking can cause big economic losses, most of the research so far hasn't really helped farmers predict or prevent it effectively. Studies have looked into why cracking happens, focusing on the physical and environmental factors, but they don't offer practical tools for spotting the problem early and taking action.

Our research is about figuring out how to predict cracking risk in pomegranates using RGB and thermal imaging. By capturing images of the fruit throughout the growing season and under different irrigation conditions, we're gathering detailed data that can help us spot early signs of cracking. We'll use image preprocessing techniques to clean up the data and pick out the important features that might indicate a risk of cracking.

We will use advanced AI models, like deep learning and machine learning, to predict when cracking might happen. By tapping into the detailed data from our imaging techniques, these models aim to give farmers practical insights they can use to prevent cracking and manage their crops better.

Proposed Methodology

In our approach, RGB imaging helps us detect changes in color and fine details on the fruit's surface, which might hint at where cracks could start. Meanwhile, thermal imaging allows us to see temperature differences across the fruit, highlighting areas under stress that might crack later. By combining these two technologies, we can catch early warning signs of cracking.

Data was collected from 432 pomegranate fruits of the "Wonderful" cultivar in the orchard of Kibbutz Tsora, Israel, in five imaging campaigns during the summer of 2024. The trees bearing these pomegranates were subjected to various irrigation treatments, which are known to influence the likelihood of fruit cracking. Imaging of the fruits began at the end of August and continued every two weeks until harvest, capturing the pomegranates at different stages of maturity.

To ensure our data is of high quality and suitable for analysis, we will conduct preprocessing of the collected images. This will include noise reduction, image alignment, and normalization. One useful approach in this case will be to apply the Segment Anything Model (SAM) to isolate the pomegranate surface from the background, facilitating accurate feature extraction.



Once the features are extracted, we'll conduct a correlation analysis to explore how these features relate to different irrigation treatments and the incidence of fruit cracking. By examining sequential images, we'll track how these features and cracking progress over time, helping us understand how irrigation practices influence cracking risk.

With these insights, we'll develop AI models to predict cracking risk. We'll explore techniques like Convolutional Neural Networks (CNNs) because they're great at automatically learning and extracting complex features from images (Zhao et al., 2024).

Current progress

First Data Collection Completed: RGB and thermal images of pomegranates have been acquired under different irrigation treatments throughout the growing season. This dataset serves as the foundation for further analysis.

Image Preprocessing in progress: Work has begun on processing the images but it is not done yet.

AI Model Development Not Started Yet: Once preprocessing is complete, the next step will be developing and training an AI model to predict the likelihood of pomegranate cracking.

Bibliography

[1] Singh, A., Shukla, A. K., & Meghwal, P. R. (2020). Fruit cracking in pomegranate: Extent, cause, and management – A review. *International Journal of Fruit Science*, 20(sup3), S1234-S1253.

<https://doi.org/10.1080/15538362.2020.1784074>

[2] Chang, B.-M., Zhang, Y., & Keller, M. (2019). Softening at the onset of grape ripening alters fruit rheological properties and decreases splitting resistance. *Planta*.

<https://link.springer.com/article/10.1007/s00425-019-03226-y>

[3] Joshi, M., Schmilovitch, Z., & Ginzberg, I. (2021). Pomegranate fruit growth and skin characteristics in hot and dry climate. *Frontiers in Plant Science*, 12, 1797-1803.

<https://www.frontiersin.org/articles/10.3389/fpls.2021.725479/full>

[4] Zhao, X., Wang, L., Zhang, Y., Han, X., Deveci, M., & Parmar, M. (2024). A review of convolutional neural networks in computer vision. *Artificial Intelligence Review*. Accepted: 4 February 2024 / Published online: 23 March 2024.

<https://link.springer.com/article/10.1007/s10462-024-10721-6>

