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A Theoretical Framework for Computer Vision-Based Sorting and Grading of Coffee Cherries: An African Perspective for Yirgacheffe Cooperatives

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Abstract

The Yirgacheffe region produces high-quality coffee, but many cooperatives depend on manual cherry sorting and grading. This process is labour-intensive, subjective, and inconsistent, which can constrain profitability. An accessible, objective quality assessment method is needed to enhance value for smallholder farmers. This article proposes a theoretical framework for a computer vision system to automate the sorting and grading of coffee cherries at cooperative processing plants. Its primary objective is to define the core components and data requirements for a system tailored to the specific needs, constraints, and cherry characteristics of Yirgacheffe cooperatives. The framework is developed through a synthesis of established computer vision methodologies, including image acquisition, preprocessing, feature extraction, and classification algorithms. It integrates domain knowledge of coffee agronomy and post-harvest processing, accounting for practical constraints such as variable lighting and infrastructure in rural facilities. Key insights: The framework identifies colour and morphological features as most critical for initial sorting. It proposes a hierarchical model where colour sorting precedes defect detection. A principal insight is that the classification algorithm requires training on a locally representative dataset, as features defining premium Yirgacheffe quality may differ from other regions. The theoretical framework establishes a viable foundation

for developing a practical computer vision system. It demonstrates how automated grading can be conceptually adapted to the context of Yirgacheffe cooperatives to promote standardisation and add value. Future work should prioritise curating a comprehensive, annotated image dataset of Yirgacheffe cherries. Pilot implementations are recommended to test the framework's assumptions and refine the model using real-world performance data from cooperative processing lines. computer vision, coffee grading, post-harvest processing, agricultural automation, Yirgacheffe, cooperatives This work provides a novel theoretical framework for adapting computer vision technology to the specific agricultural and infrastructural context of African coffee cooperatives, with a focus on the Yirgacheffe region.