Beyond the Naked Eye: Computer Vision for Detecting Brown Marmorated Stink Bug and Its Punctures

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***Abstract*—In this article, we introduce machine learning (ML) techniques developed for the monitoring of the brown marmorated stink bug (BMSB), a significant agricultural pest responsible for considerable crop damage worldwide. The HALY.ID project, initiated in early 2021, aims to enhance BMSB monitoring through the utilization of information and communication technology methods. We employ computer vision techniques on RGB images captured by drones and investigate the performance of deep neural networks to evaluate the impact of this invasive species on crop yields in orchards around Europe. Specifically, we evaluate the single shot multibox detector, detection transformer, YOLOv5, YOLOv9, and YOLOv10 architectures for full-level and patch-level image analysis, respectively. To improve detection accuracy, we experiment with shortwave infrared hyperspectral imaging (SWIR-HSI) in laboratory settings. Given that pheromone baited traps are the most accepted tools for pest detection by field operators, we also propose an Internet of Things sticky trap with an integrated camera equipped with lightweight convolutional neural networks models operating "on the edge" in this resource constrained system. In addition, we develop a client–server application for real-time bug detection, integrating the ML models to provide accessible results to farmers. Lastly, we explore effective postharvesting strategies using SWIR-HSI images to detect insect punctures invisible to the naked eye, thereby enhancing the quality of marketable fruit.**

***Index Terms*—Brown marmorated stink bug (BMSB), computer vision algorithms, hyperspectral imaging, insect detection, RGB imaging, unmanned aerial vehicles (UAVs).**

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I. INTRODUCTION

THE European project HALY.ID [1], started at the beginning of 2021, aimed at monitoring the *Halyomorpha halys*, also known as the brown marmorated stink bug (BMSB), a global agricultural pest causing significant damage to crops. The BMSB, originating from East Asia [2], is a highly destructive and polyphagous pest, infesting various fruit trees, such as pears, peaches, and apricots, leading to substantial crop damage worldwide with significant economic impact. Its global spread is facilitated by human activities, such as international trade, and worsened by climate change, causing significant financial losses, notably in regions, such as Italy's Emilia Romagna [3], which is known for its fertile orchards. Current monitoring methods primarily rely on traps, which use lures with aggregation pheromones that attract bugs in the vicinity, increasing the local damages [3]. Unfortunately, once the BMSB specimens are discovered to be present in an orchard, there is no specific chemical defense except for the use of broad-spectrum systemic pesticides that disrupt integrated pest management strategies, and raise environmental and human health concerns for customers.

To address the challenges posed by BMSB, and in particular those related to computer vision, HALY.ID proposes to leverage machine learning (ML) technologies [4] in the following research activities.

1) We worked with RGB images of insects "in the field" and generated diverse image datasets from various campaigns and imaging platforms, smartphones, drones, and open