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The Queen in the Crowd: Lightweight Computer Vision for Real-Time Beehive Monitoring

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Healthy bee colonies depend entirely on the presence of a single queen, yet finding her among tens of thousands of identical-looking workers requires beekeepers to manually inspect frames, a process that is disruptive, time-consuming, and impractical at scale. Some systems use audio-based hive tools to infer whether a queen is present, but they cannot indicate where she is within the hive (Orlowska et al., 2021). This research addresses that gap by asking: Can a lightweight AI model, running on everyday hardware, reliably detect the queen bee from live hive video?

To answer this, I have proposed an AI-powered system that visually locates the queen bee in live hive footage using a lightweight deep learning model, YOLOv8n, small enough to run on a standard laptop CPU with no specialized hardware required. Since the queen appears very rarely in hive footage, I used a method that creates extra training images by placing queen photos onto different hive backgrounds, giving the model more examples to learn from (Ghiasi et al., 2021). I then deployed the trained model into a three-tier web and mobile dashboard that streams live hive video, highlights the queen's location with a bounding box, and displays colony status in real time.

The system reliably detects the queen and processes video fast enough for genuine live use on ordinary laptop hardware, without needing any specialised AI infrastructure. Beyond queen detection, I designed the dashboard so it can be extended to monitor broader colony health indicators, such as brood patterns and drone presence.

In this presentation, I will demonstrate how a lightweight AI model was trained, deployed, and made accessible through a live web dashboard, showing that powerful computer vision tools do not require expensive hardware and can have real-world impact in precision agriculture and ecosystem conservation.

Keywords
YOLOv8, deep learning, Queen bee detection, real-time monitoring, precision beekeeping, web dashboard

References

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