Fast and Automatic Inspection of

Citrus HLB and Other Common Defects

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Introduction

Citrus Industry in Florida

Oranges for juice processing in Florida

- **95% of harvested oranges are used for processed products**

- **Tons of citrus fruit are dumped in citrus packing house**

- **Post-harvest inspection: separation and quality control for fresh, or value-added products**

Images from The Packer
(http://www.thepacker.com/)

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Huanglongbing (HLB)

HLB or Citrus greening disease

- **Caused by the bacterium with a carrier Asian citrus psyllids**
- **No known cure found**
- **The most destructive of all citrus diseases in history**
- **34.4% decrease in total orange production in 2013-14 (USDA, 2015)**

HLB severely impacts qualities of crops

- **Green colored (sometimes partially)**
- **Small fruit with bitter taste**
- **Infected fruit may remain and be harvested along with healthy oranges**

HLB infected oranges

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Post-harvest Fruit Inspection

Objectives

OVERALL GOAL

To automate post-harvest orange inspection process to identify Healthy, HLB , wind scar, and rust mite.

SPECIFIC GOAL

To combine parallel computing and machine learning in the system for faster, and practical application
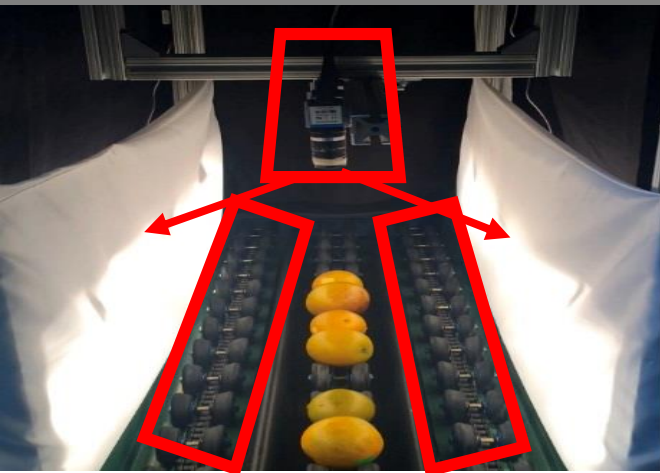

Safety

Competitiveness

Profitability

Current Technologies

Customized Conveyor

6-feet long customized conveyor system (Three lane labeler, Durand-Wayland Inc.)

Circular polarizer

Reduce glare and reflections (25 mm Circular Polarizing Filter, Tiffen)
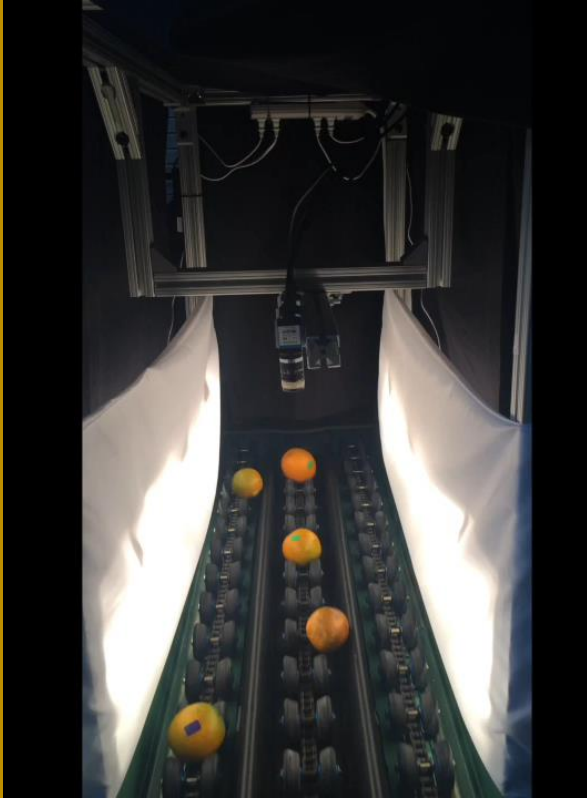
4 USB 3.0 Cameras

640 by 480 pixels
Installed 5.35 cm apart
(DFK 23UV024,
The Imaging Source)

Image Acquisition Hardware

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Video Acquisition

Traveling speed of 60.3 cm/sec

Videos were recorded at 30 frames/sec (640 by 480) in uncompressed RGB format

Customized video acquisition software was developed by Precision Ag. Lab.

Fruit Types

HLB

Wind scar
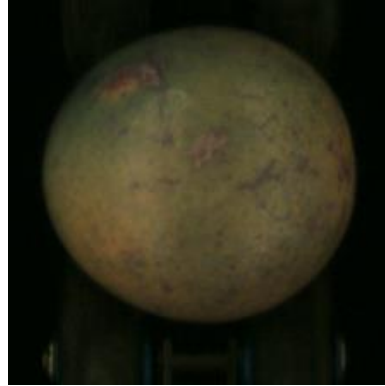
Healthy

Rust mite

The fruit samples were collected in a commercial citrus packing house in Ft. Pierce, Florida.

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Computer Vision Algorithm

Image processing
Background removal
Centroid location tracking

Fruit tracking system

Machine learning
algorithm

Classification

Citrus defect identification

Computer Vision Algorithm

**Image processing
Background removal
Centroid location tracking**

Fruit tracking system

Classification

Citrus defect identification

Parallel Computing for Fast Processing
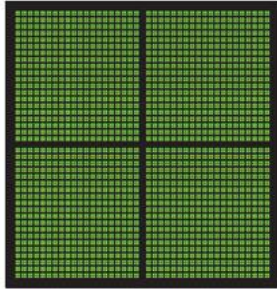
✅ **CPU (Central Processing Unit) VS GPU**

- Image processing traditionally done by CPU
- Technology have made enormous advancement in performance of parallel computing recent years

CPU MULTIPLE CORES

GPU THOUSANDS OF CORES

✅ **Graphical Processing Unit (GPU)**

- Used be called as "graphic card"
- Specialized electronic circuit to manipulate images
- Increase computing performance dramatically
- Practical prices ($200~$700) is an advantage

Background Removal

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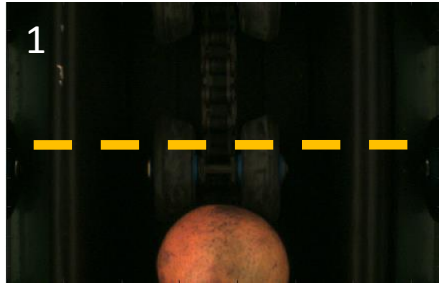UNIVERSITY of FLORIDA | Precision Agriculture Lab.
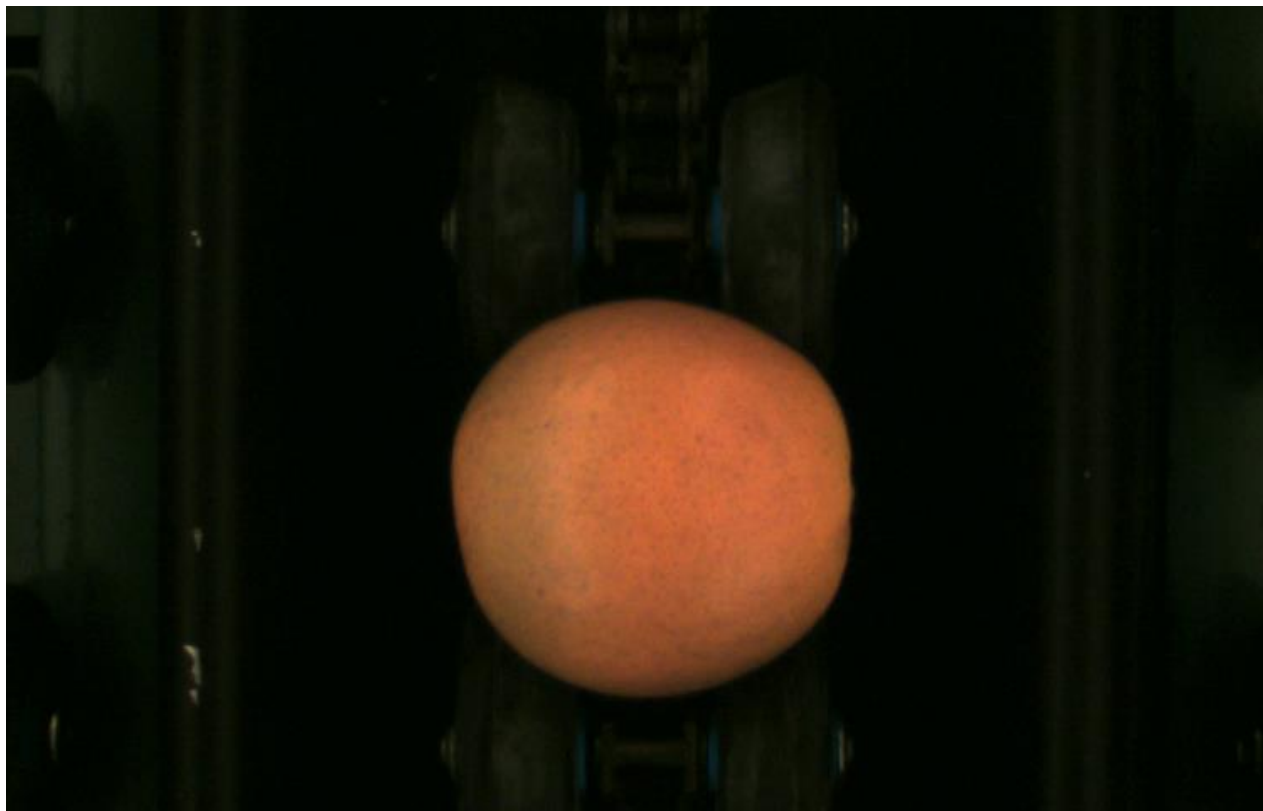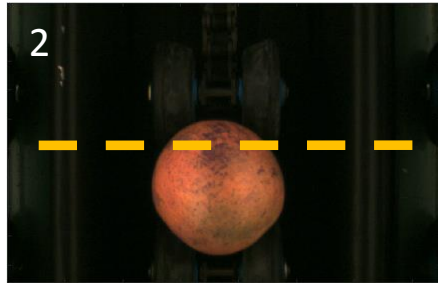
Background Removal
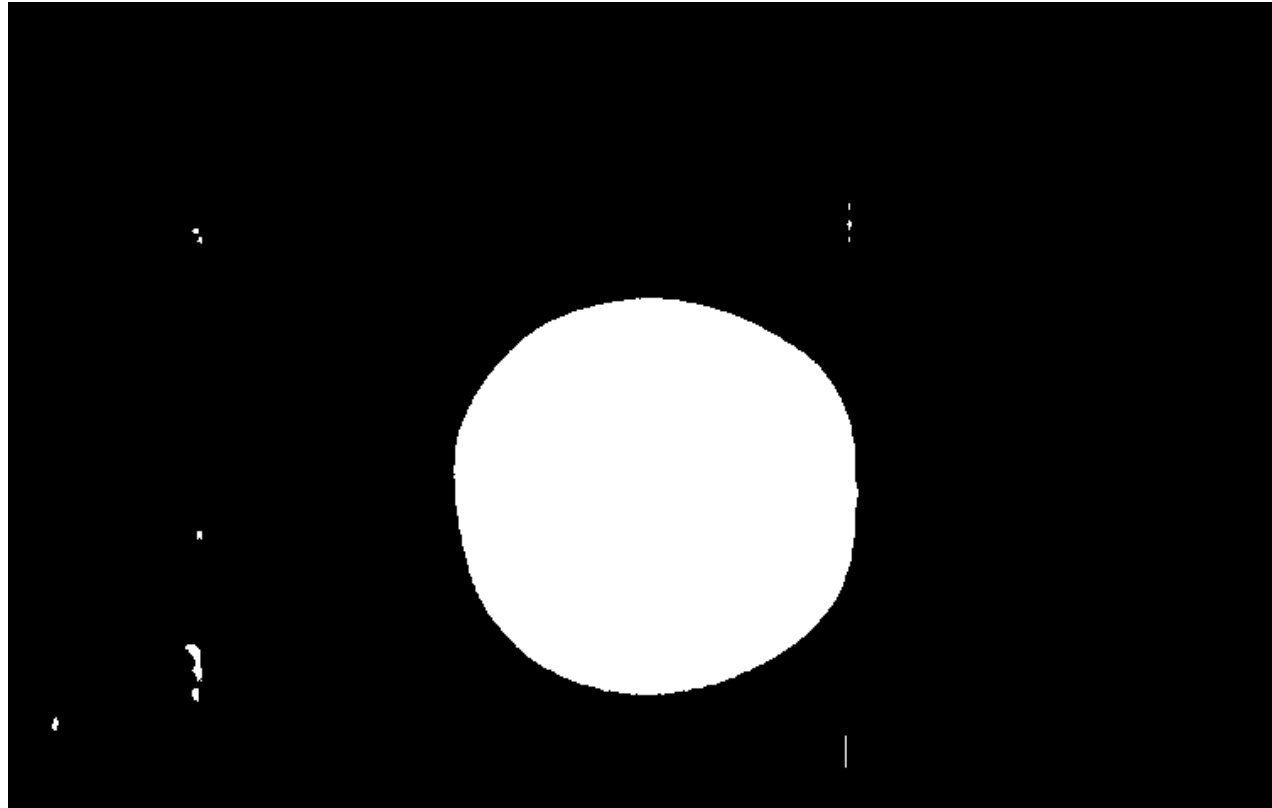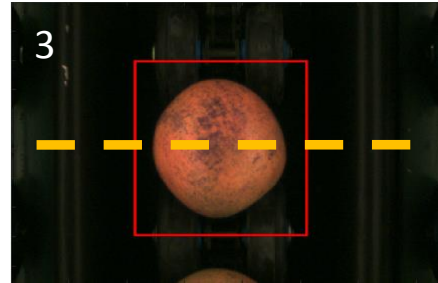
Fruit Tracking System

- GPU-enabled image and video processing
    1. Remove background pixels by thresholding
    2. Check if a scene contained any oranges
    3. Calculate and track centroid of an orange object in consecutive image
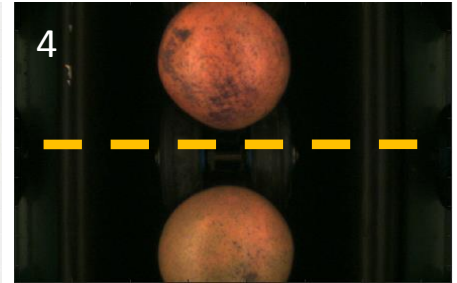

|			
Tracking system turned on when an orange firstly appeared	Positions of the centroid of orange compared with yellow line	When the centroid location passed the center line, orange image was immediately extracted	Tracking system turns off and starts again if there is newly appeared orange

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Fruit Tracking System
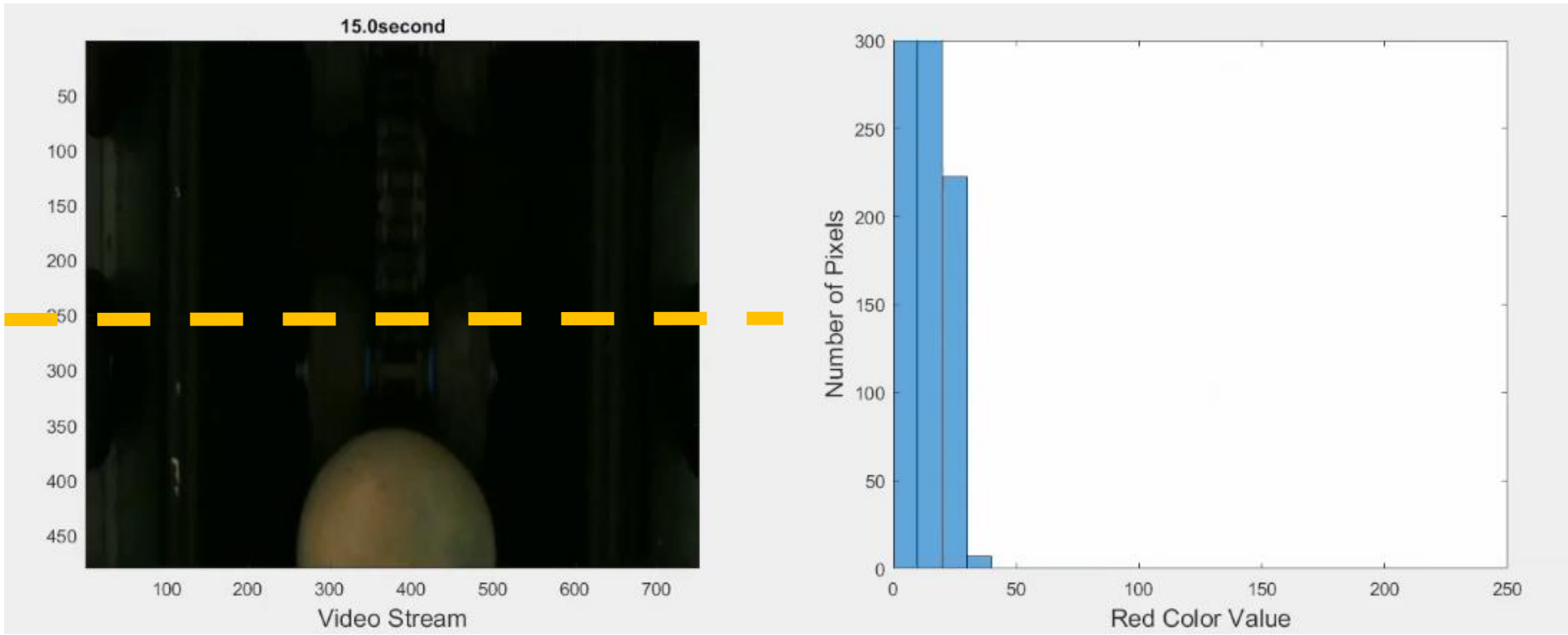
Computer Vision Algorithm

Machine learning algorithm

Fruit tracking system

Classification

Citrus defect identification

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What is Machine Learning?

✅ We train machines to learn!

- Sometimes we encounter problems for which it's really hard to write a computer program to solve.

- We develop an algorithm that a computer can look at thousands of examples
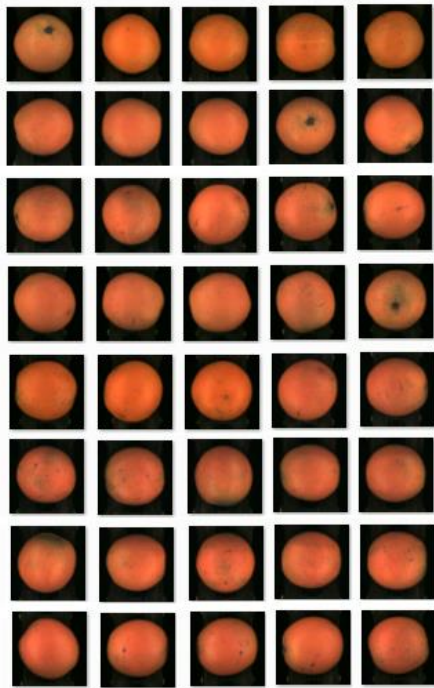- Computer uses those experiences to solve the new situation, like human does.
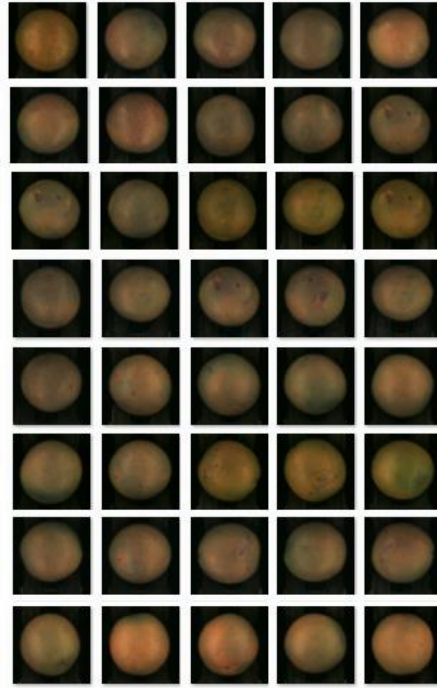
Is this zero or six...?

Images from : http://nikhilbuduma.com/2014/12/29/deep-learning-in-a-nutshell/

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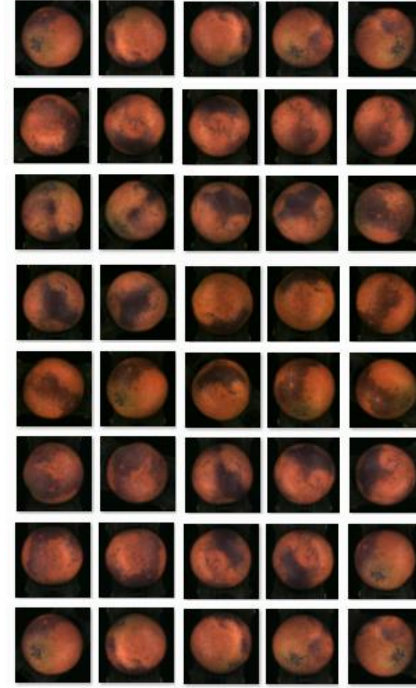UNIVERSITY of FLORIDA|Precision Agriculture Lab.
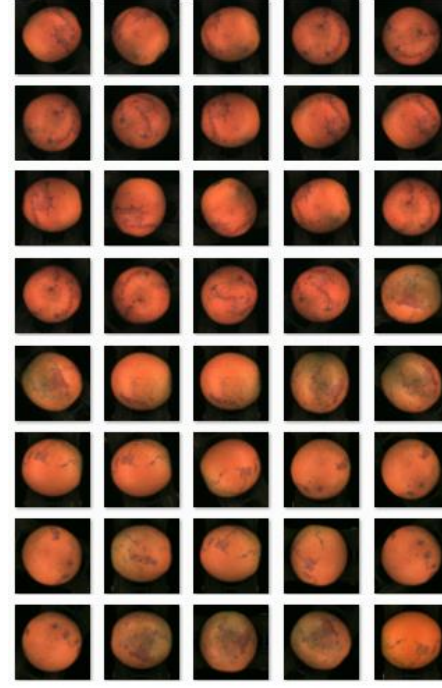
Building Fruit Samples and Learning From It

Healthy

HLB

Rust mite
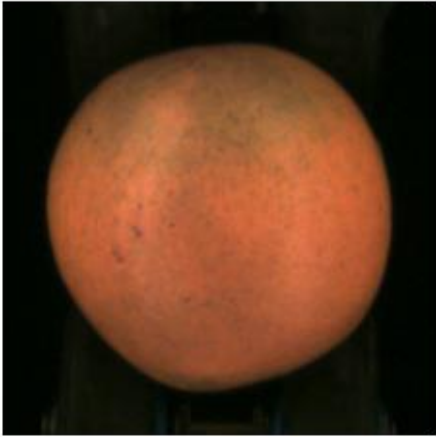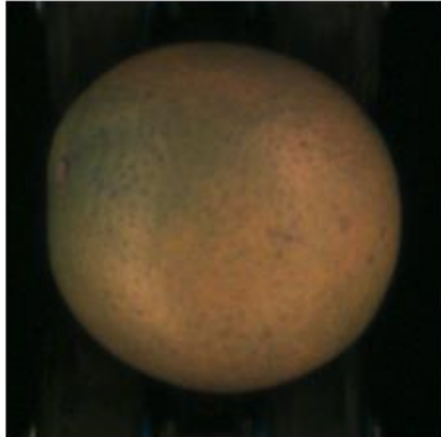
Wind scar

Result Images

✅ Machine learning tells you the probabilities for each defects of citrus
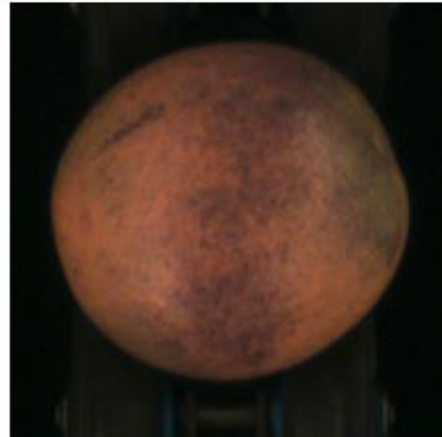

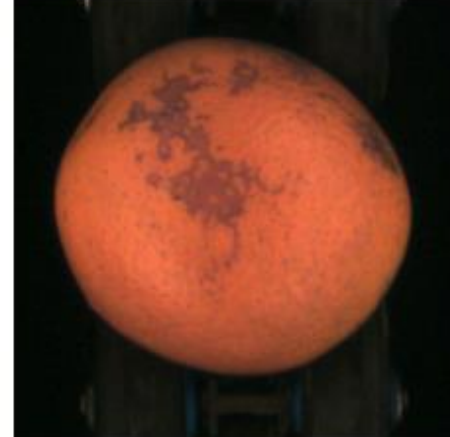
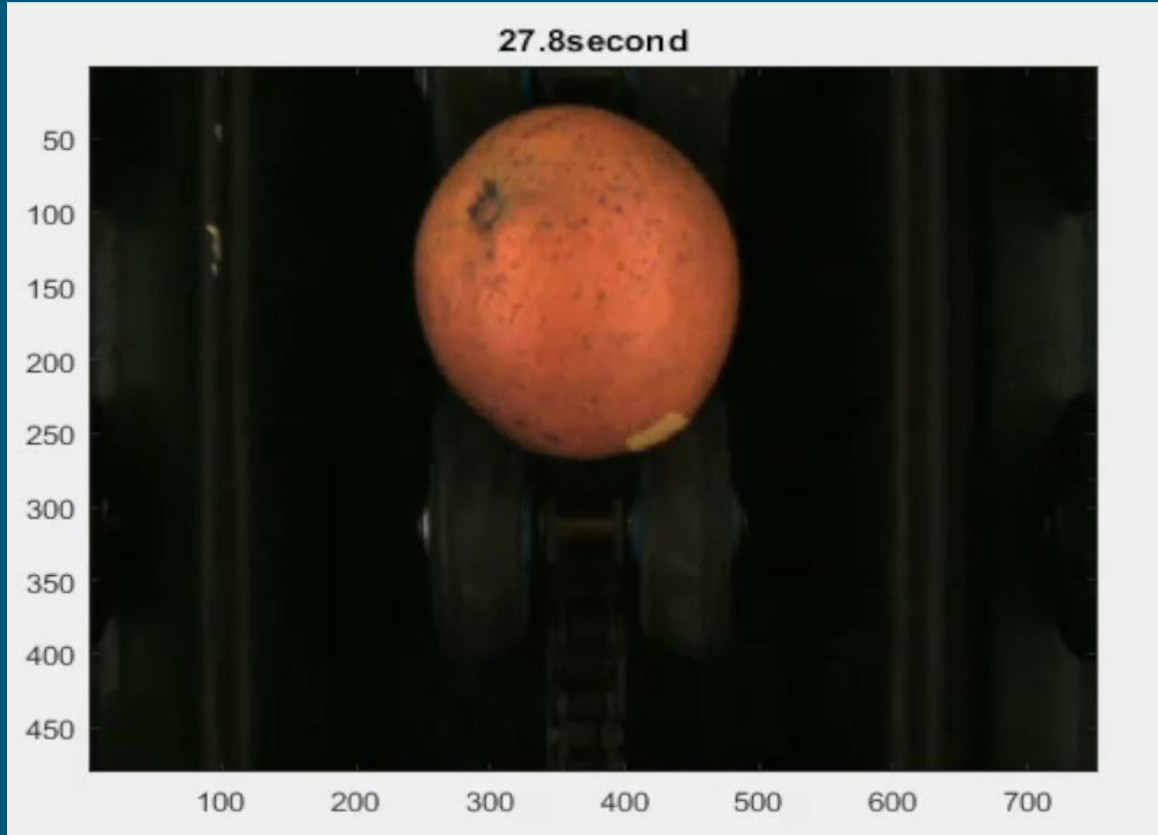Healthy (1), score 0.994   HLB (2), score 1.000   Rust mite (3), score 0.995   Wind scar (4), score 0.958

Simulated Real-time Processing

Processing time:
    44.7 ms/image
    corresponding to
    178.8 ms/orange
    (5.4 oranges/sec)

Results

✅ Validation Result: majority voting among 4 images.

Actual class

Predicted class	Healthy	HLB	Rust mite	Wind scar
Healthy	**51 (91.1)**	0 (0)	0 (0)	1 (1.4)
HLB	3 (5.4)	**94 (94.9)**	2 (2.8)	8 (10.8)
Rust mite	0 (0)	0 (0)	**67 (93.1)**	3 (4.1)
Wind scar	2 (1.4)	5 (5.1)	3 (4.2)	**62 (83.8)**

Confusion matrix (Percentage in parenthesis)

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Summary

Summaries & Future Plans

Remark1
The post-harvest HLB inspection system was developed, and had the processing speed of 5.4 oranges/sec.

Remark2
More samples (1000+ samples/types) for better accuracy (optimally over 95%, currently we have 83.8%).

Future Work1
Hardware upgrade, and software optimization: 2-3 times faster than current speed.

Future Work2
Fully commercialized system: 2 to 3 years from now for 95% accuracy and 10 fruit/sec processing time.

GPU real-time video processing

Deep learning technology

Upgrading the system

CNN architecture

Acknowledgement

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Thank you for your attention

Have a nice day

FLORIDA CITRUS

Image from wallpaperscraft.com