

Machine Vision-Embedded Food Processing Automation Systems

Yang Tao, PhD, P.E.

Professor

**Bioimaging & Machine Vision (BMV) Laboratory
Fischell Department of Bioengineering
University of Maryland**



*15th International Workshop on Quality Evaluation of
Ag and fishery products Nov 19, 2019, Taiwan Univ.*



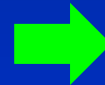
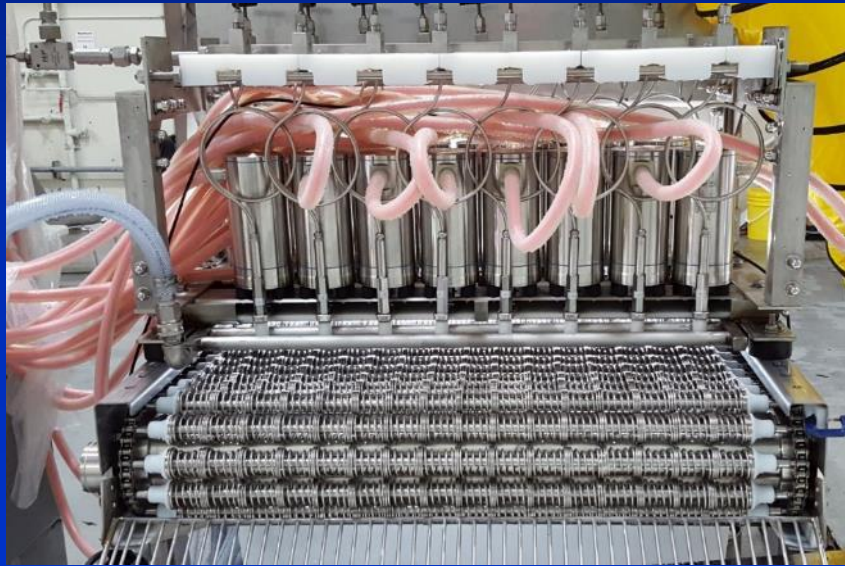
301-405-1189 ytao@umd.edu

1) Machine Vision-Guided Process Automation



Value-added food products

Automated computer Vision-guided Intelligent robotic system for De-capping strawberries (AVID) -- enabling huge productivity increase (equivalent to 120 people's productivity/each machine), resolving field labor shortages, improving human safety, and enhancing food safety.

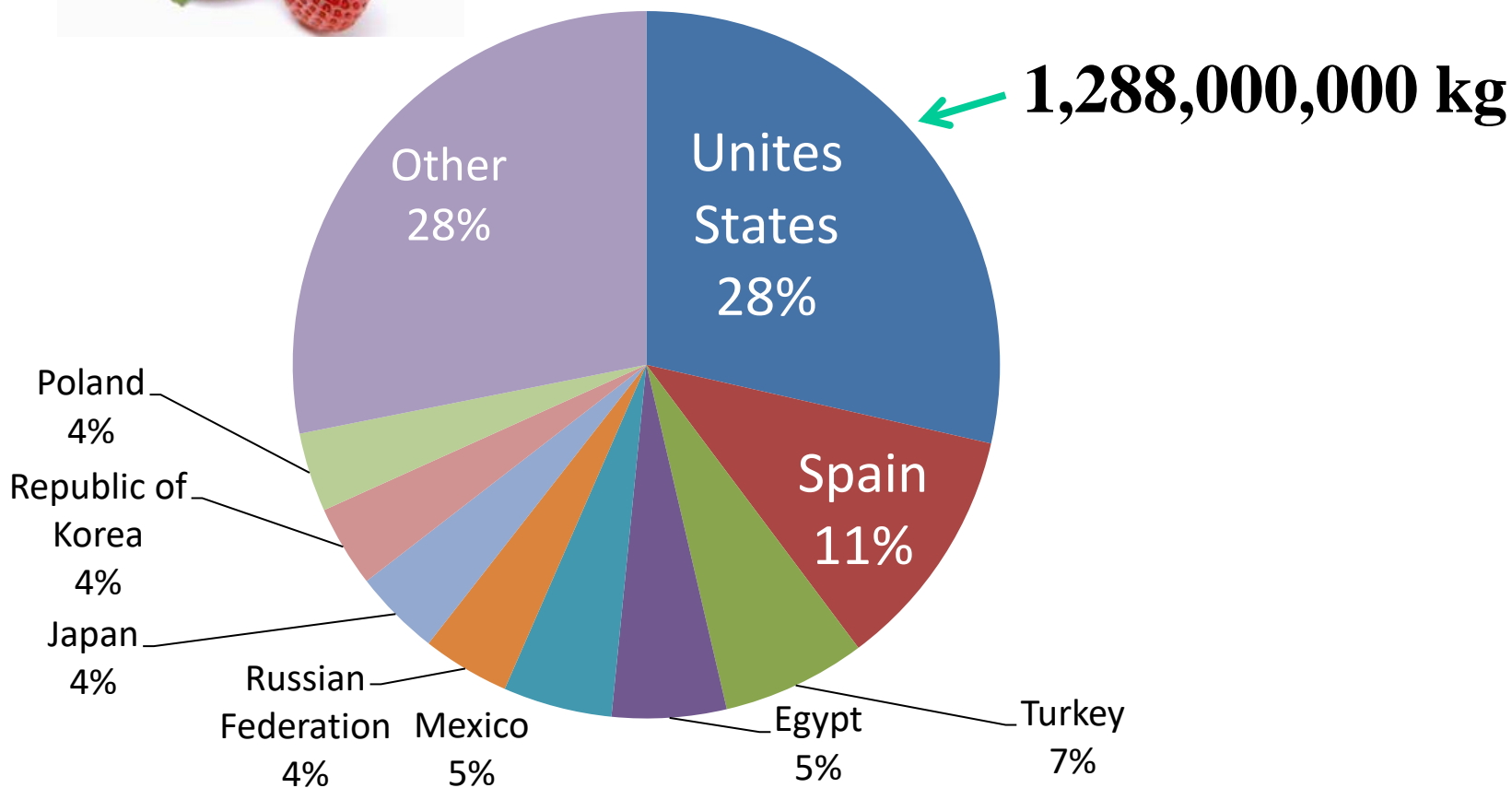


Prototype, under further development

World Strawberry Production



(4.6 Million Tons, ERS 2011)



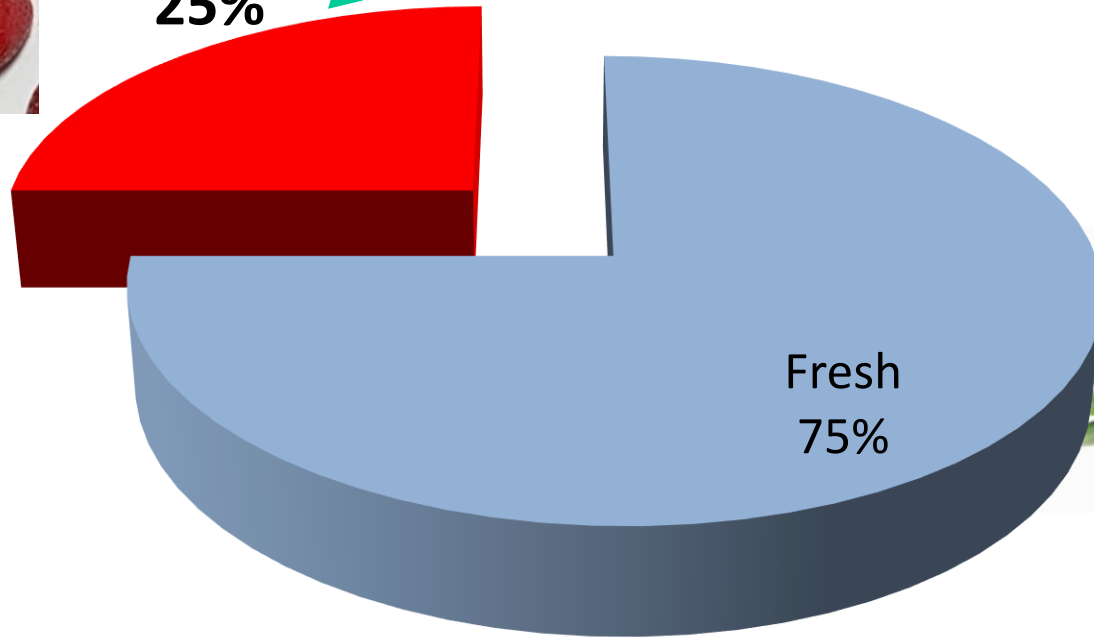
Share of world production of strawberries by country, 2011 (ERS, 2013)

U.S. Processed Strawberry



Processed (322 million kg, 627 million lbs)

25%



Value-added Strawberry Products





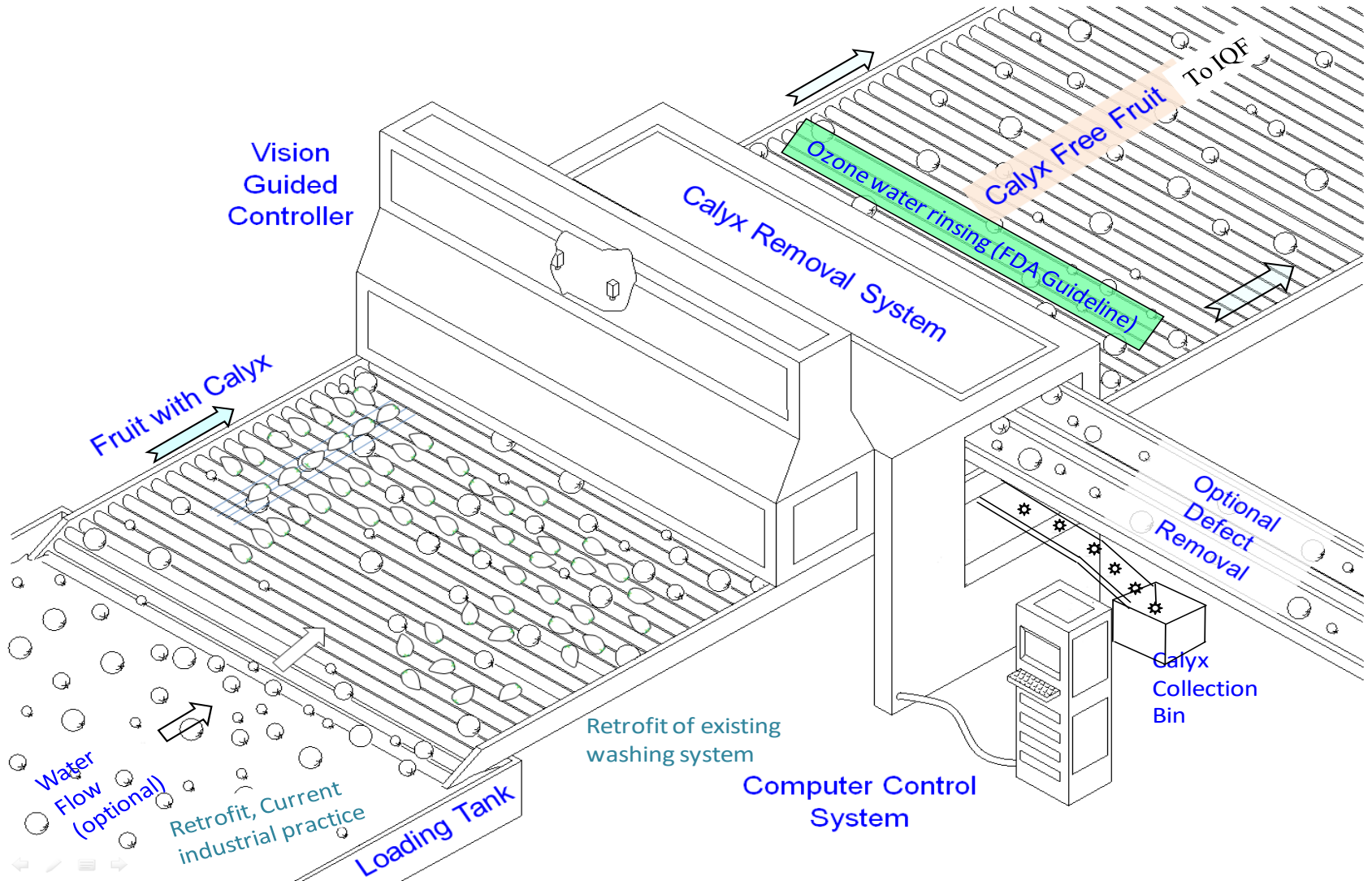
Old (current) Way

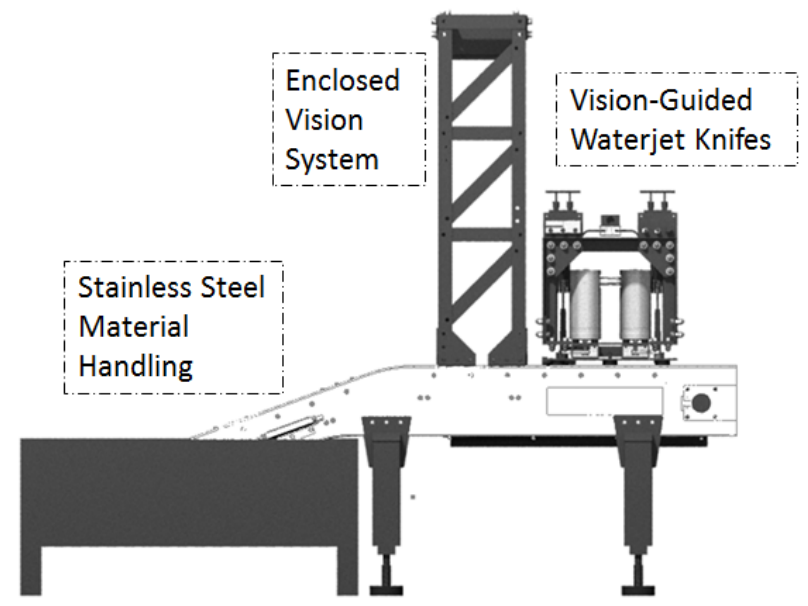
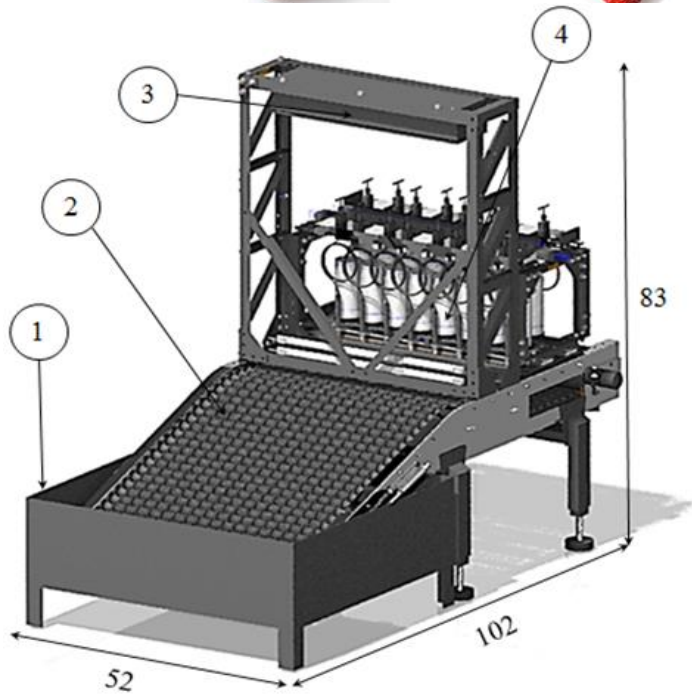
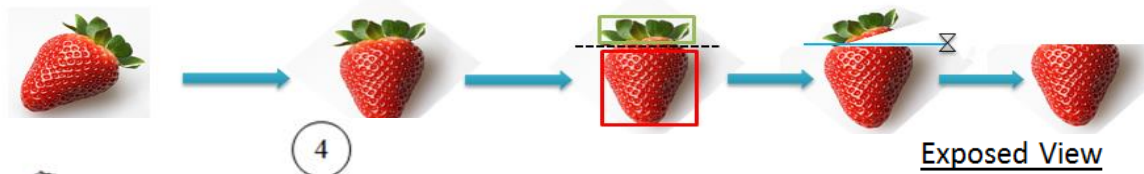
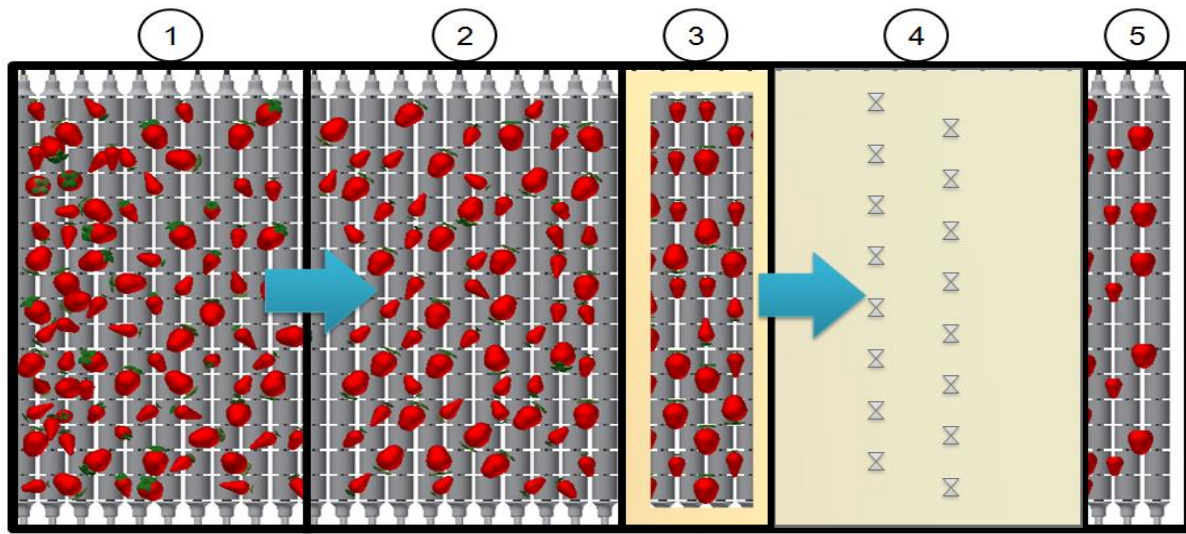


Field harvester is cutting strawberry crowns using blades. It is labor insensitive and dangerous in finger laceration.

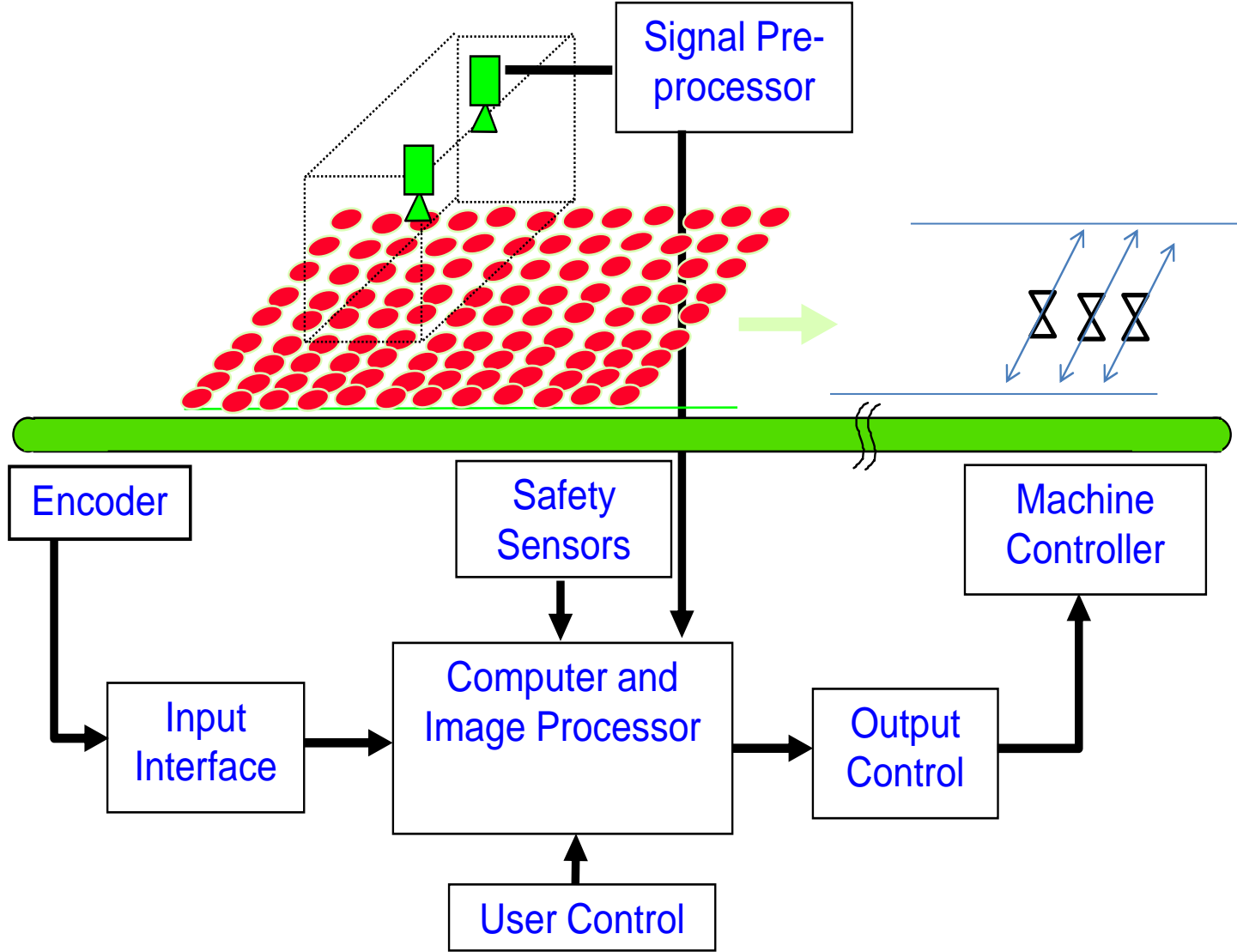
Methods

Concept of an automated de-calyx machine





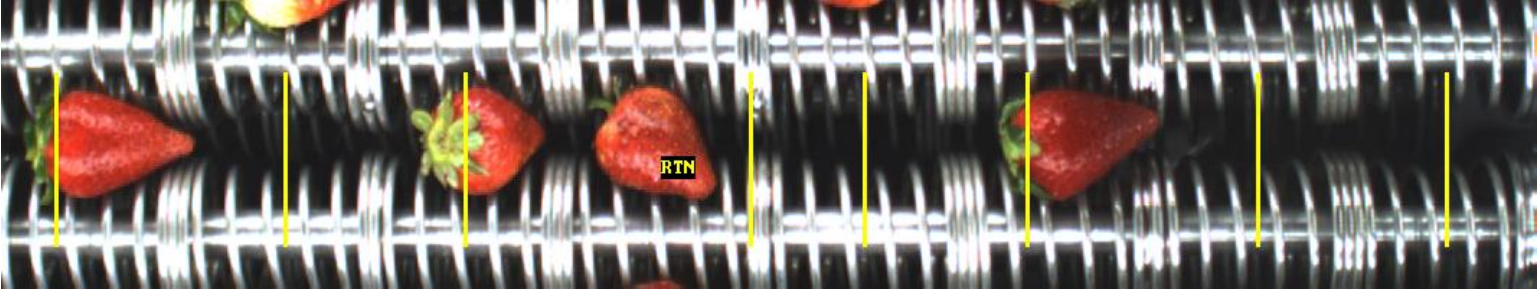
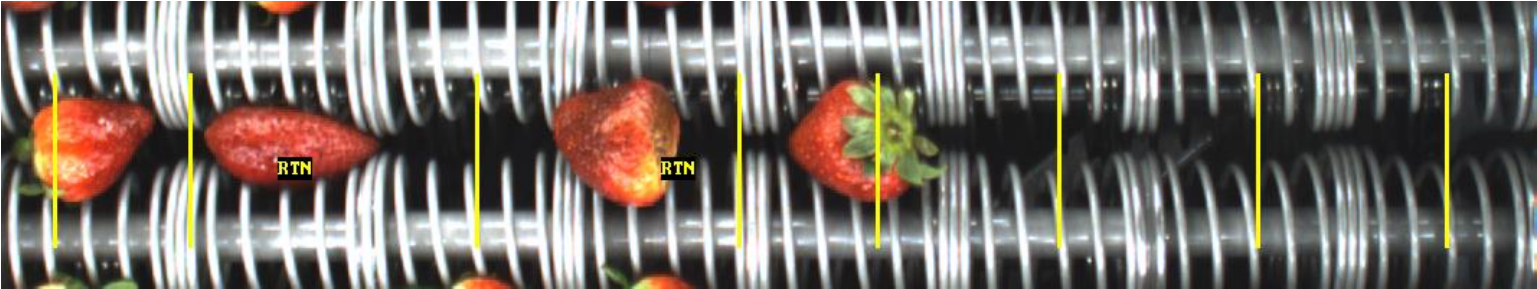
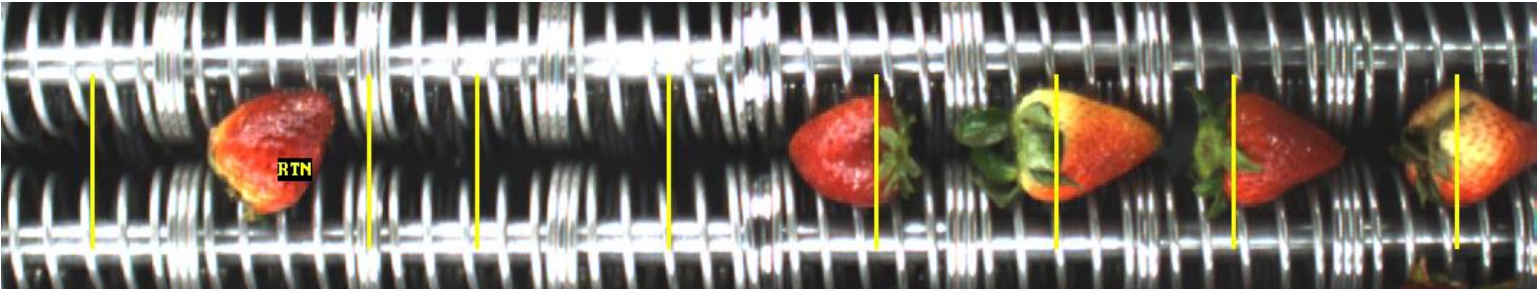
2.3 Control Diagram of Integrated Strawberry Calyx Removal System



(already been used in apple and food processing lines)

Patent Pending

Vision System Cut-line Identification



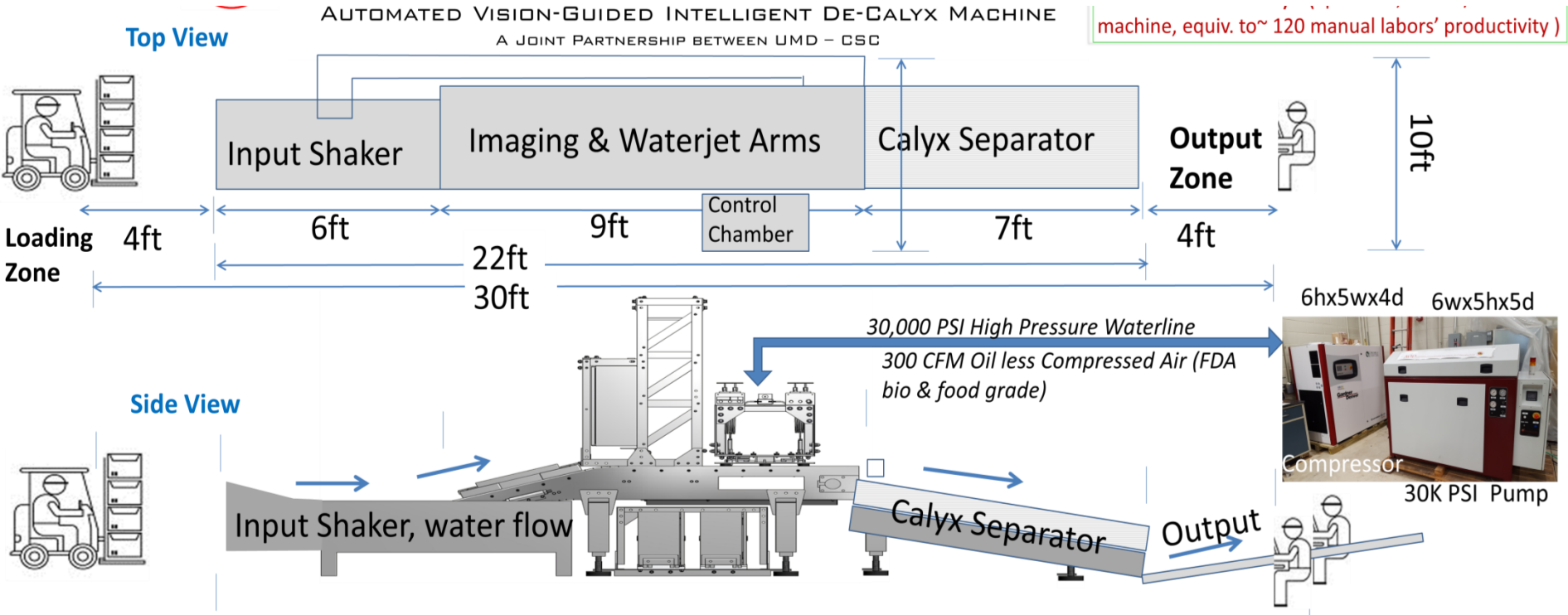
Vision-Guided Automated Strawberry Crown Removal



Patented



Product flow



In plant tests:

Tested 1 million lbs in 2016

Throughput: 10,000 lb/hr



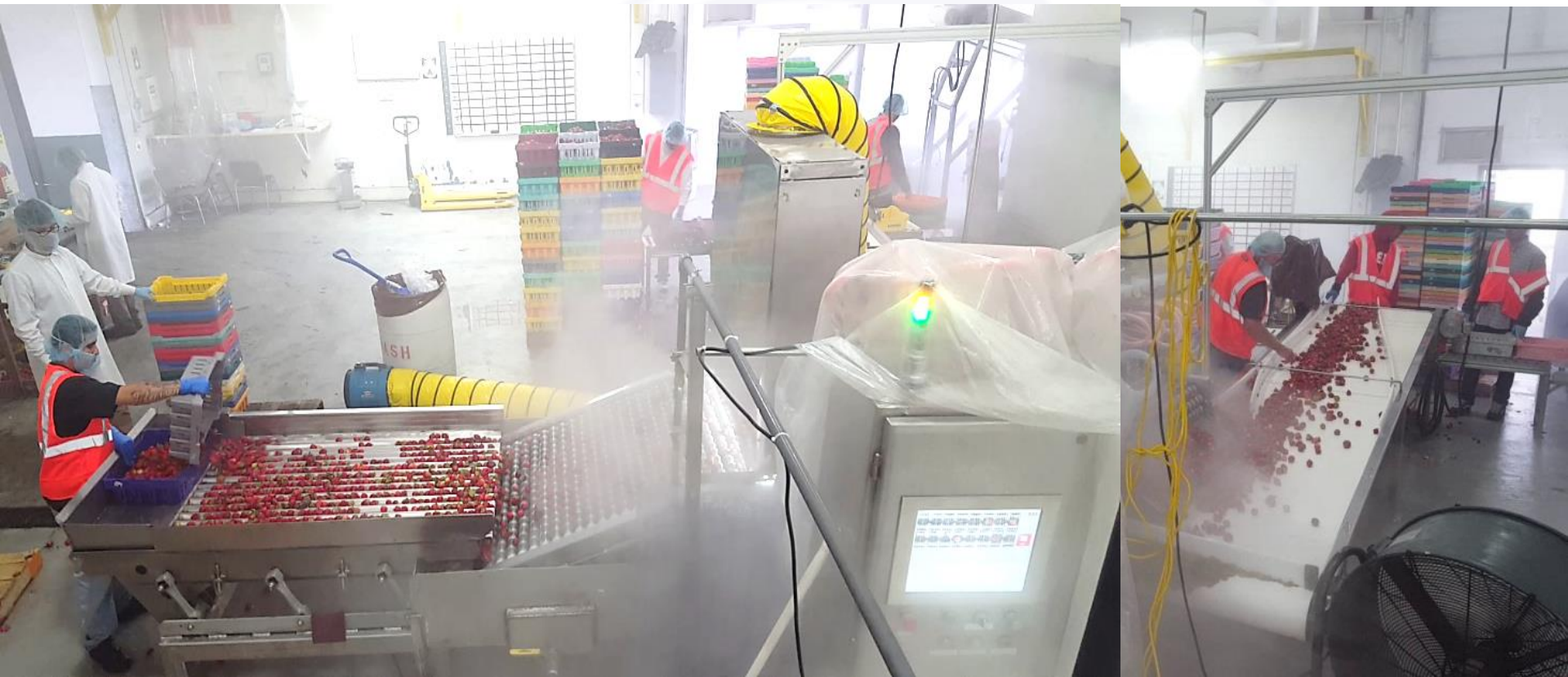
The 1st pass



In plant tests:

Tested 1 million lbs in 2016

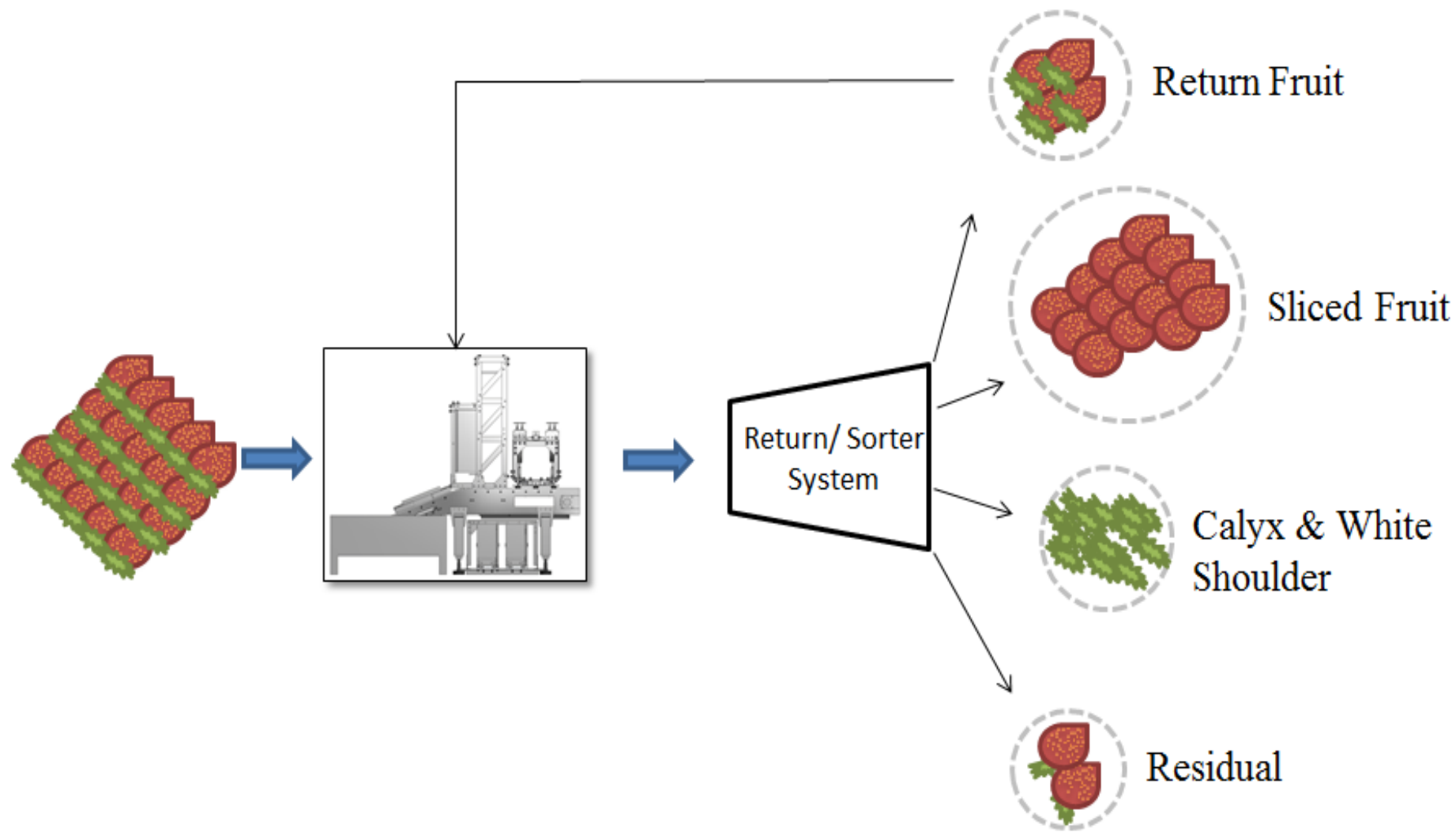
Throughput: 10,000 lb/hr



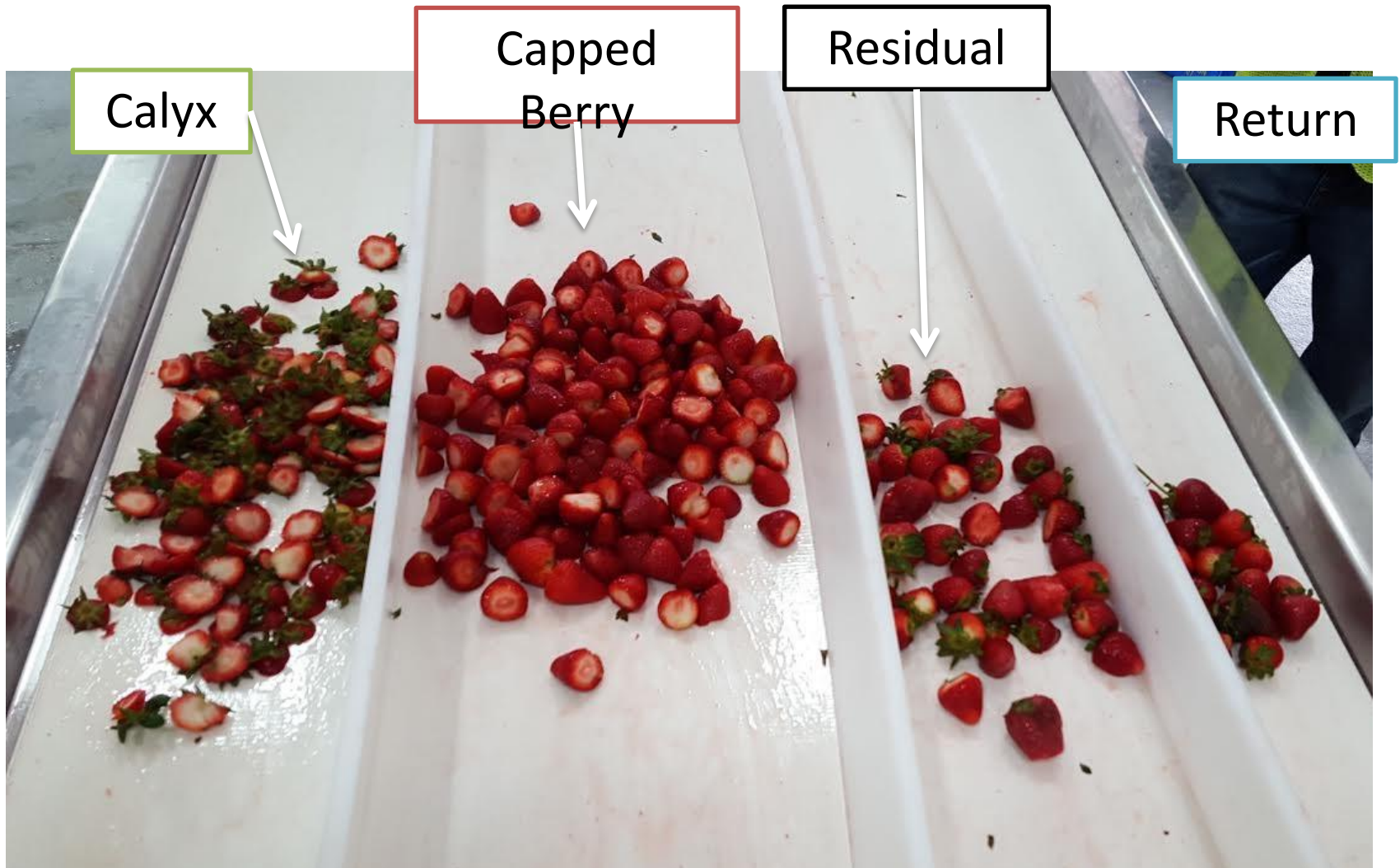


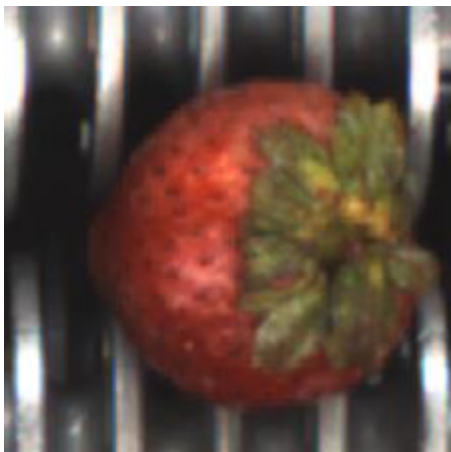
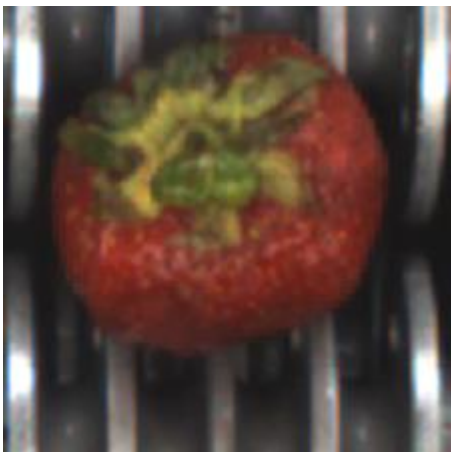
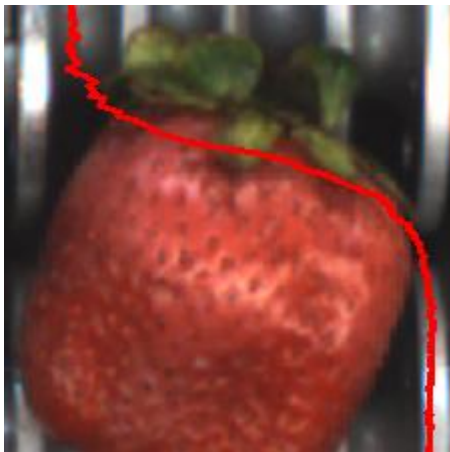
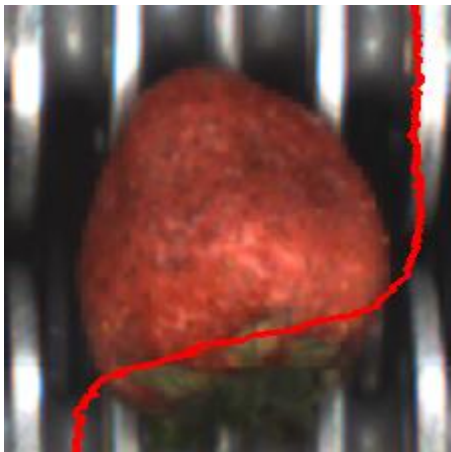
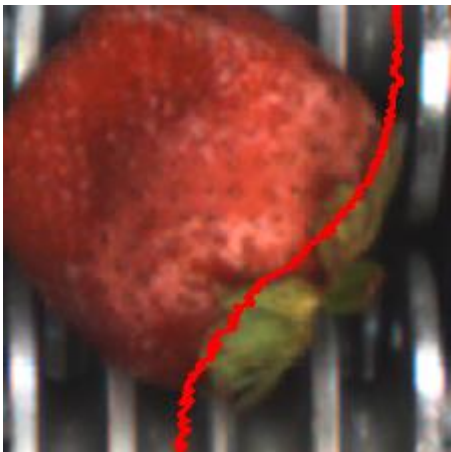
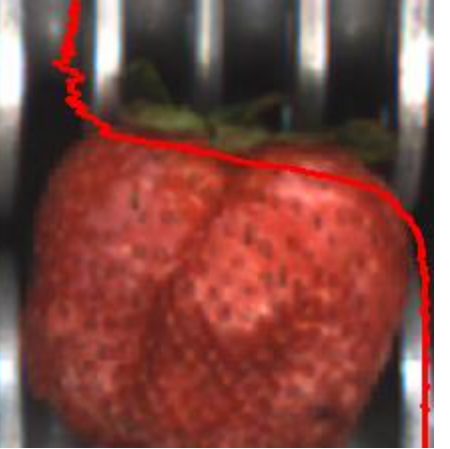
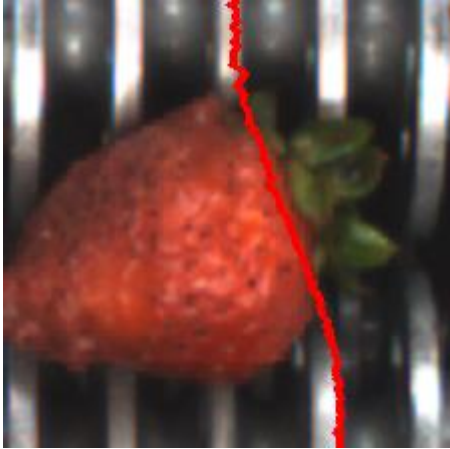
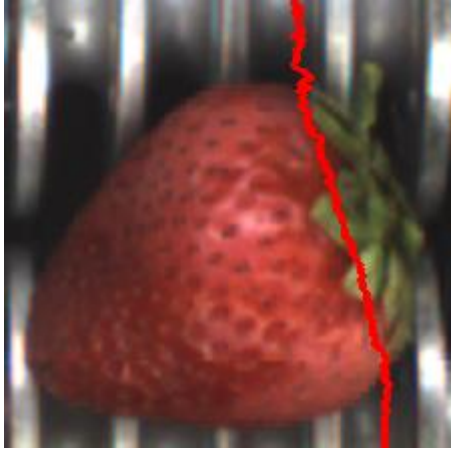
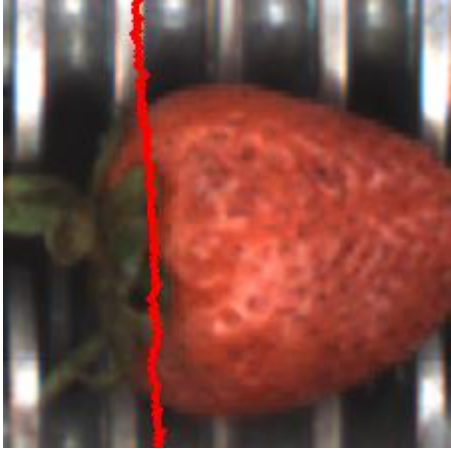
Decap Stream Output

Calyx Output
(Behind Machine)

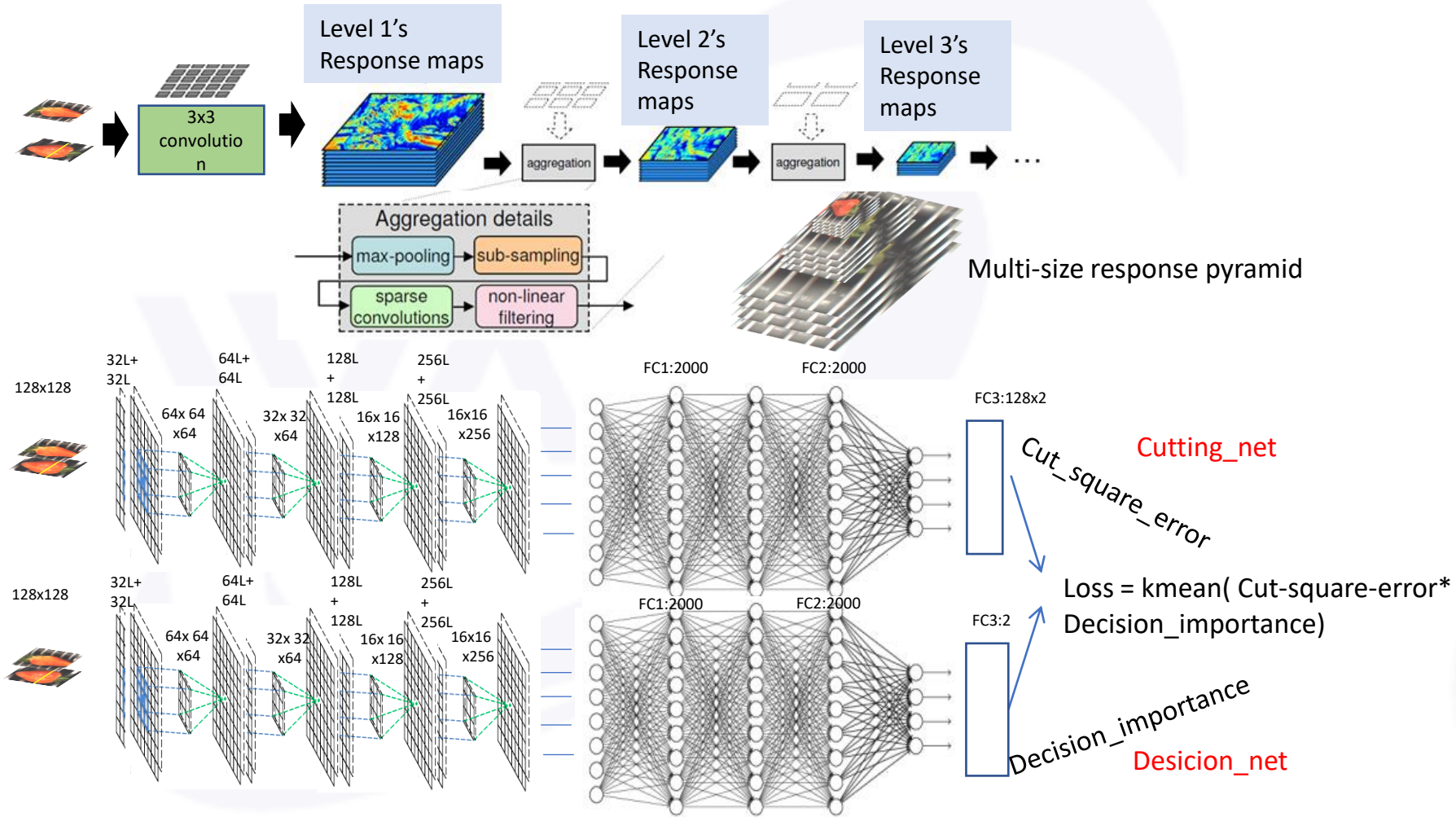


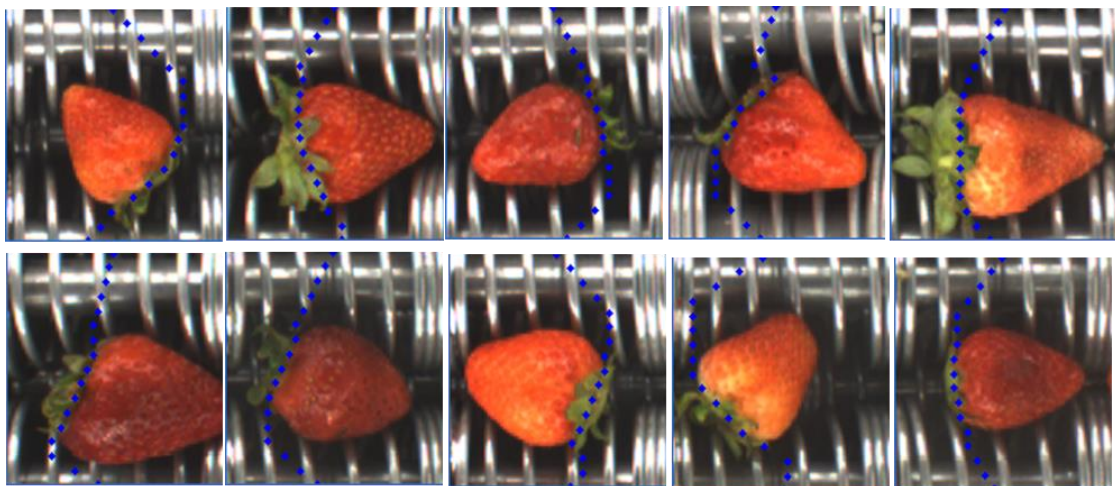
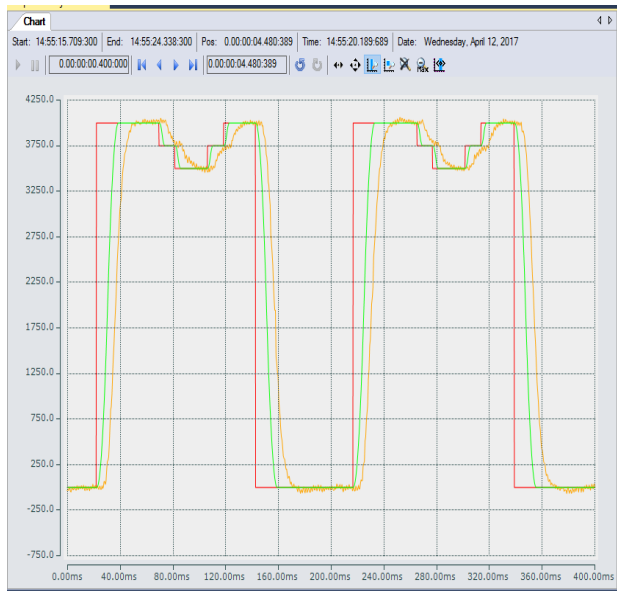
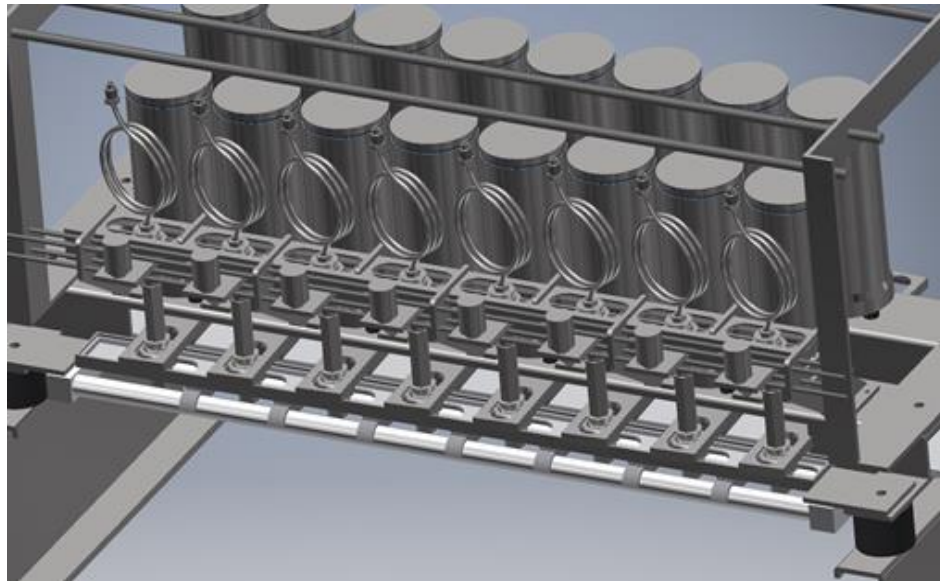
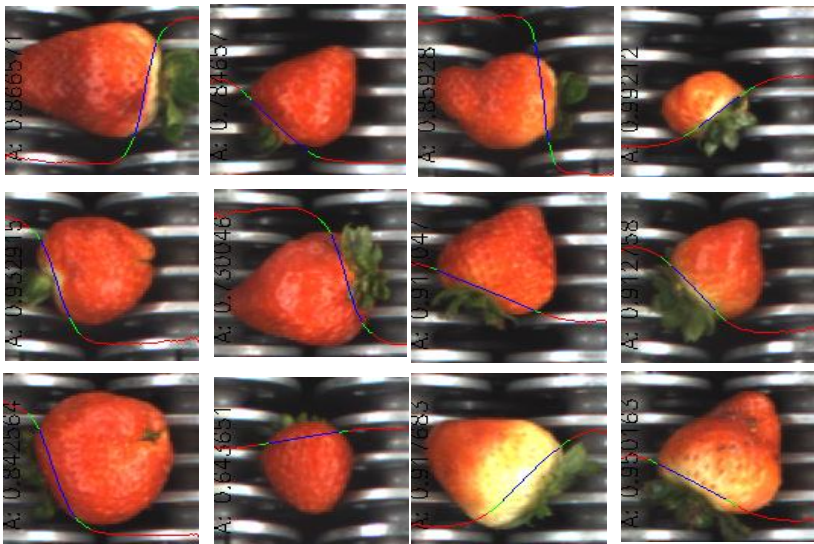
The 2nd pass of returned berry

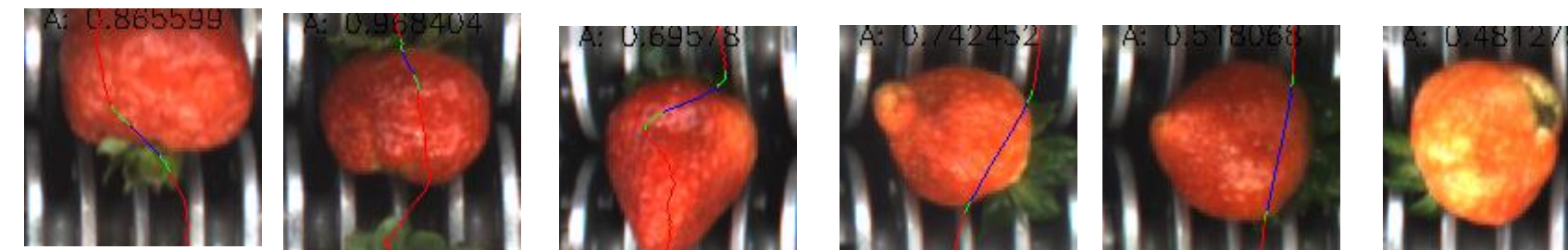
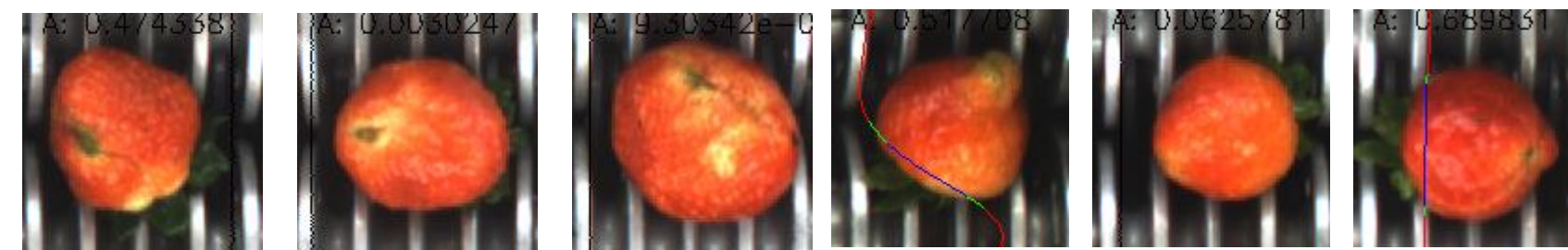
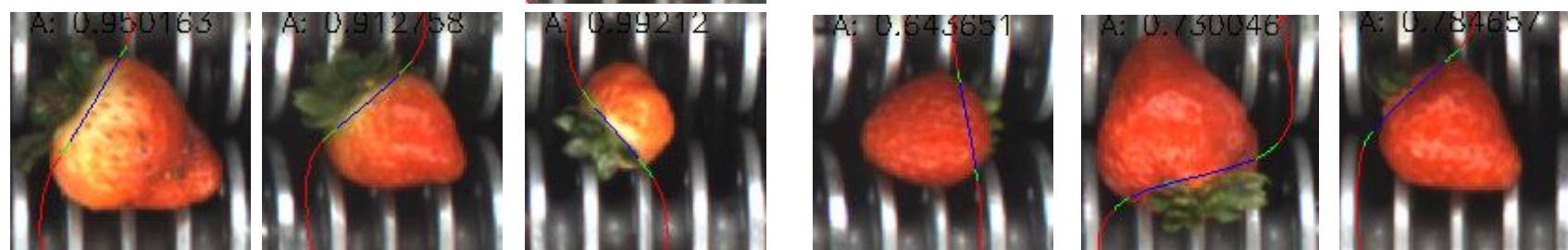
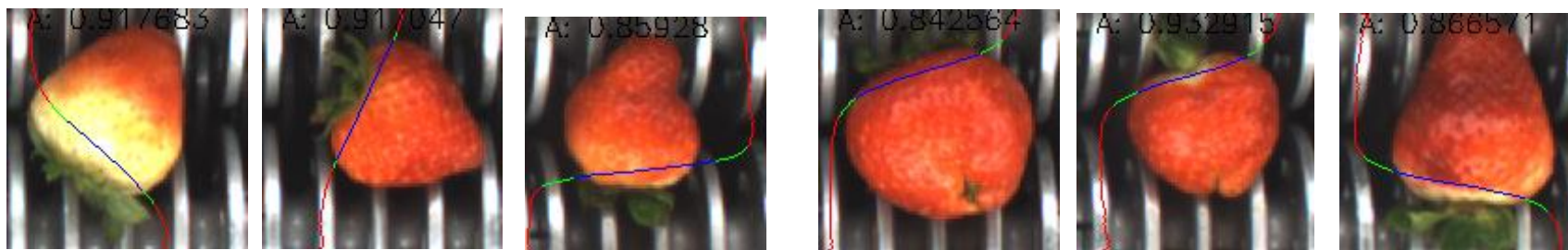




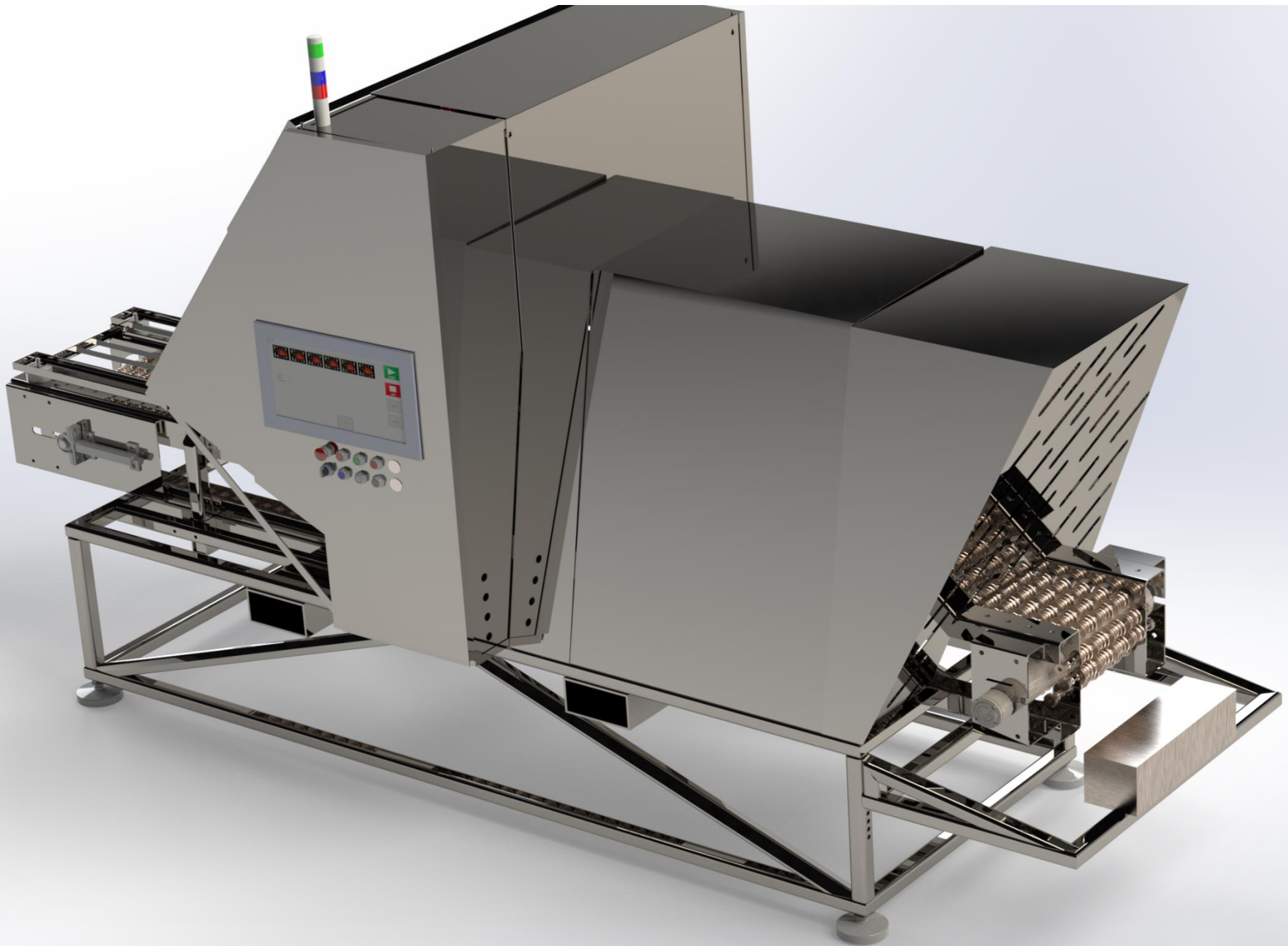
Double-Net Cascade Structure







Automated Intelligent Vision-guided De-calyxer (AVID)



Automated Intelligent Vision-guided De-calyxer (AVID)



Productivity

Equivalent to 120 people!



Manual Cut:

2 strawberries / sec

\$10 / hr



AVID Machine:

120 Strawberries / sec / shift

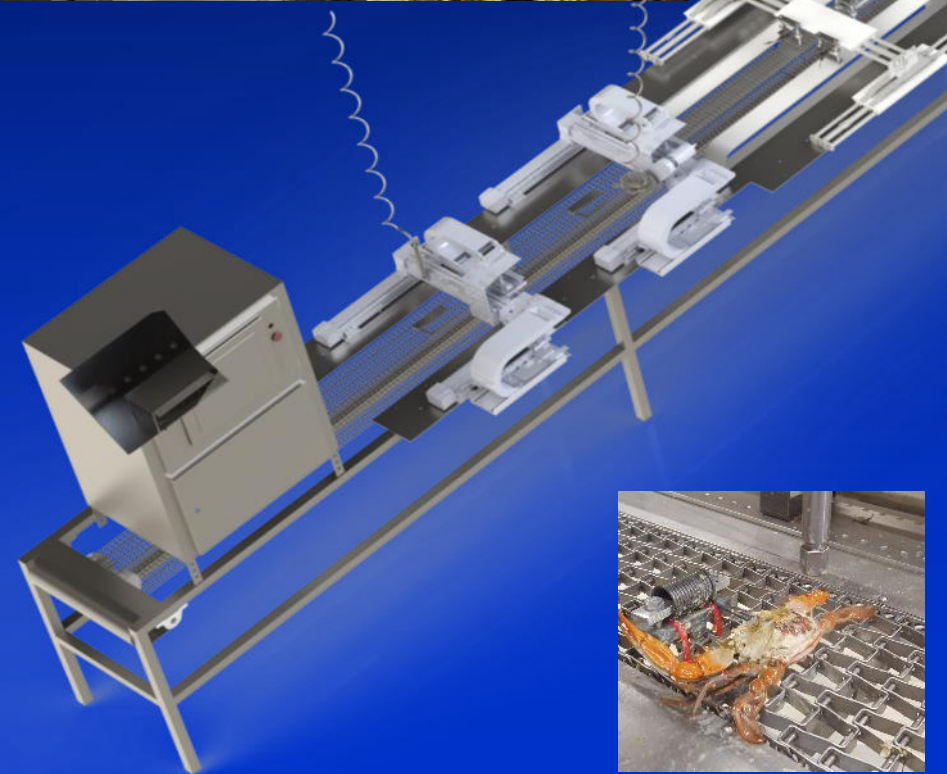
240 Strawberries / sec / 2 shift day

$\$10 \times 120 = \$1,200 / \text{hr} = \$19,200 / \text{day}$

2) Vision-Guided Robotics for Blue Crab Meat Picking Automation



- Maryland Iconic seafood
- Helping labor shortages
- Enhancing food safety and productivity (15 Fold).



Robotic crab disassembly line (Concept, under development)

Crab cake is delicious ... *very delicious.*





Introduction

Species Volume

Rank	Species	Thousand Pounds
1	Pollock	3,269,323
2	Menhaden	1,617,930
3	Salmon	1,066,047
4	Cod	702,476
5	Flatfish	579,144
6	Hakes	352,204
7	Shrimp	327,070
8	Crabs	326,393
9	Sea Herring	246,573
10	Rockfishes	164,818

Blue Crab: 158.6 million Pounds



Species Value

\$679.2 Million

\$678.7 Million - 2nd most valuable seafood in U.S

\$488 Million

Salmon : \$460 Million



Significance

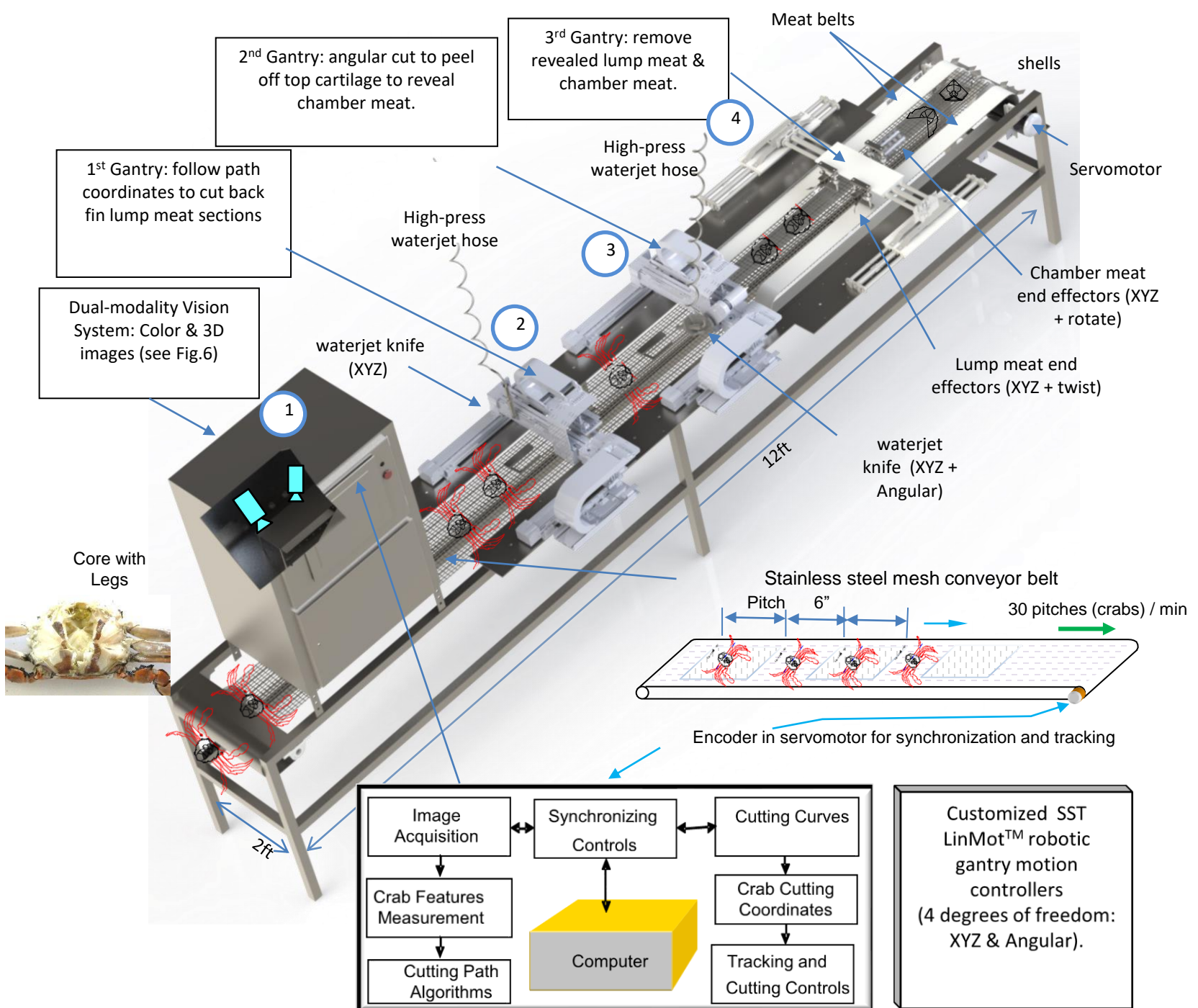


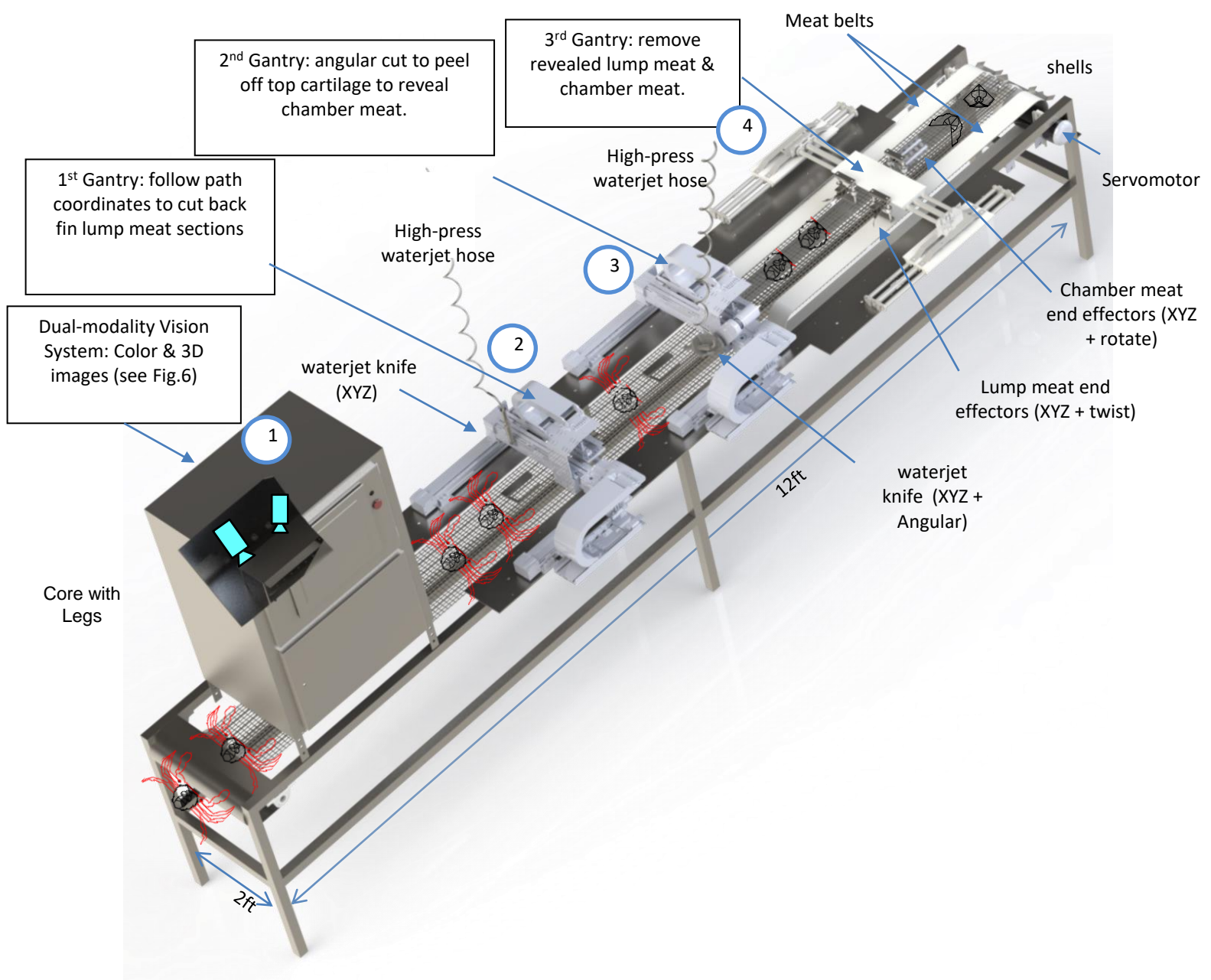
\$1.5/lb



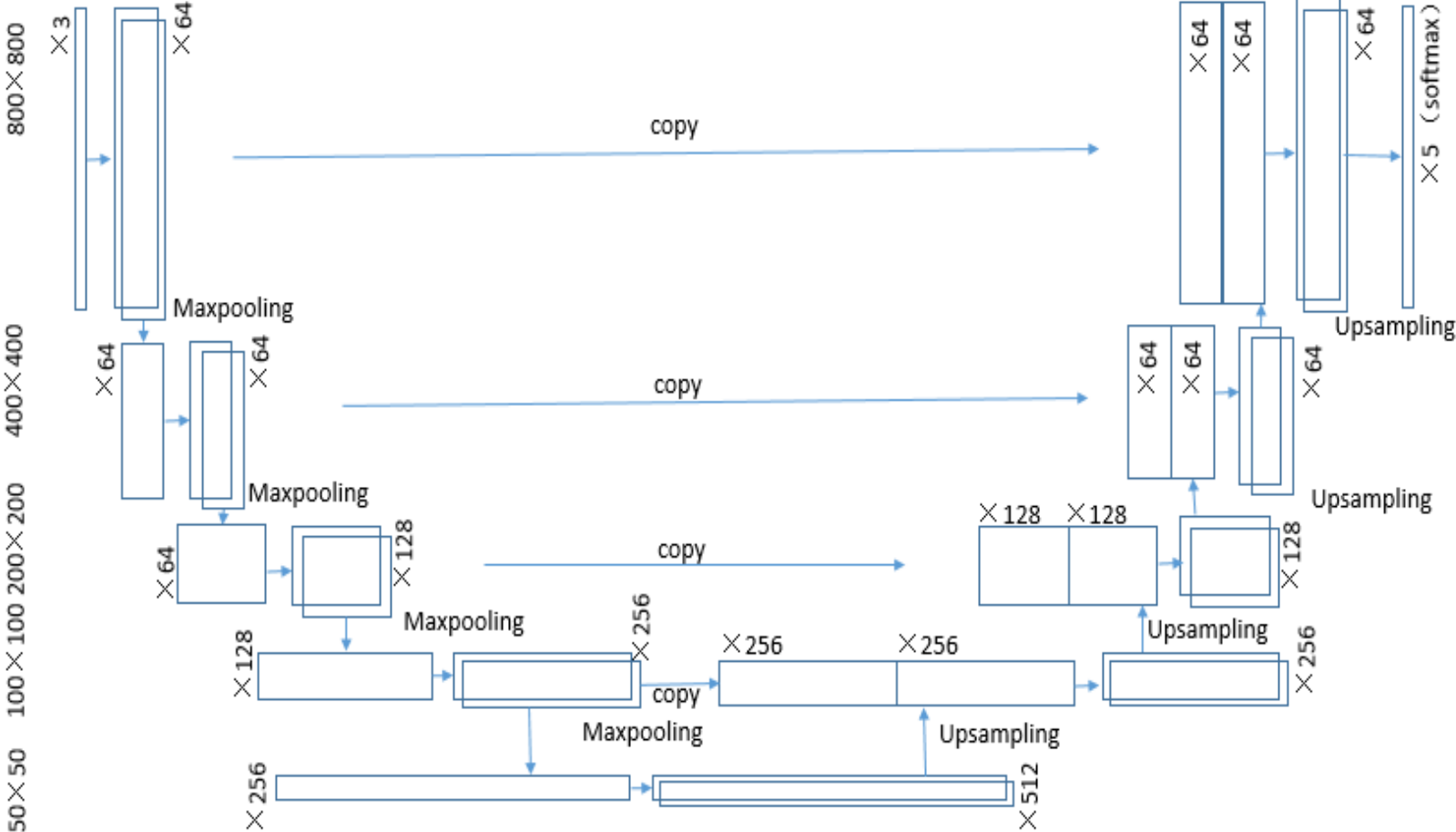
\$42.5/lb

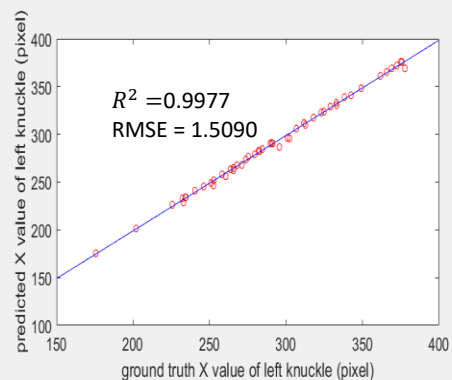
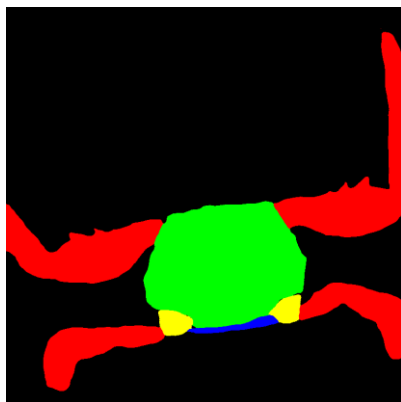
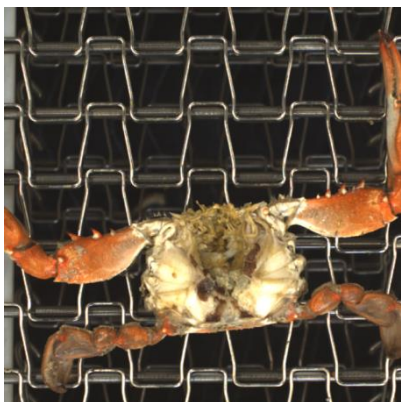




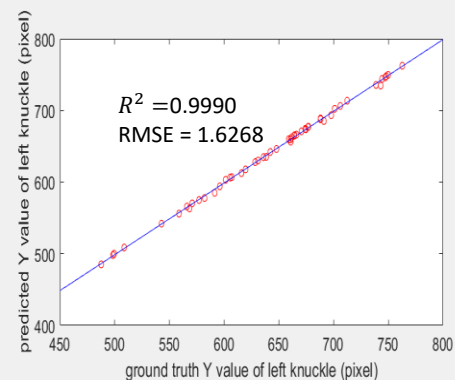


Semantic Segmentation

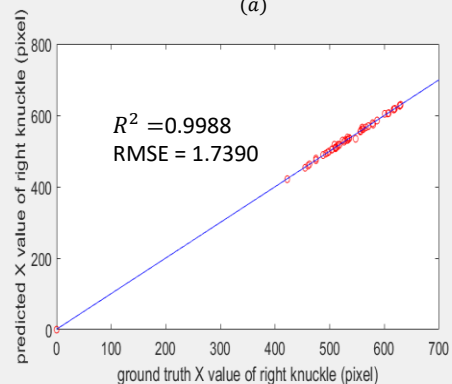




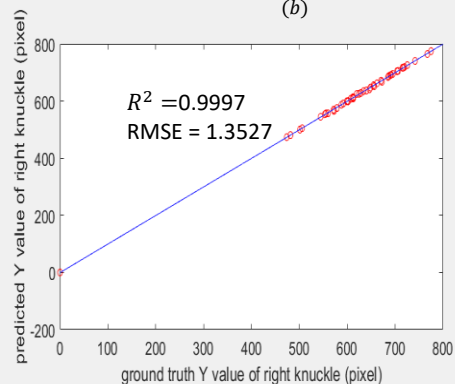
(a)



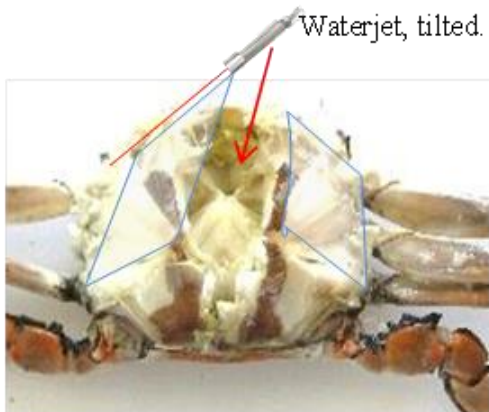
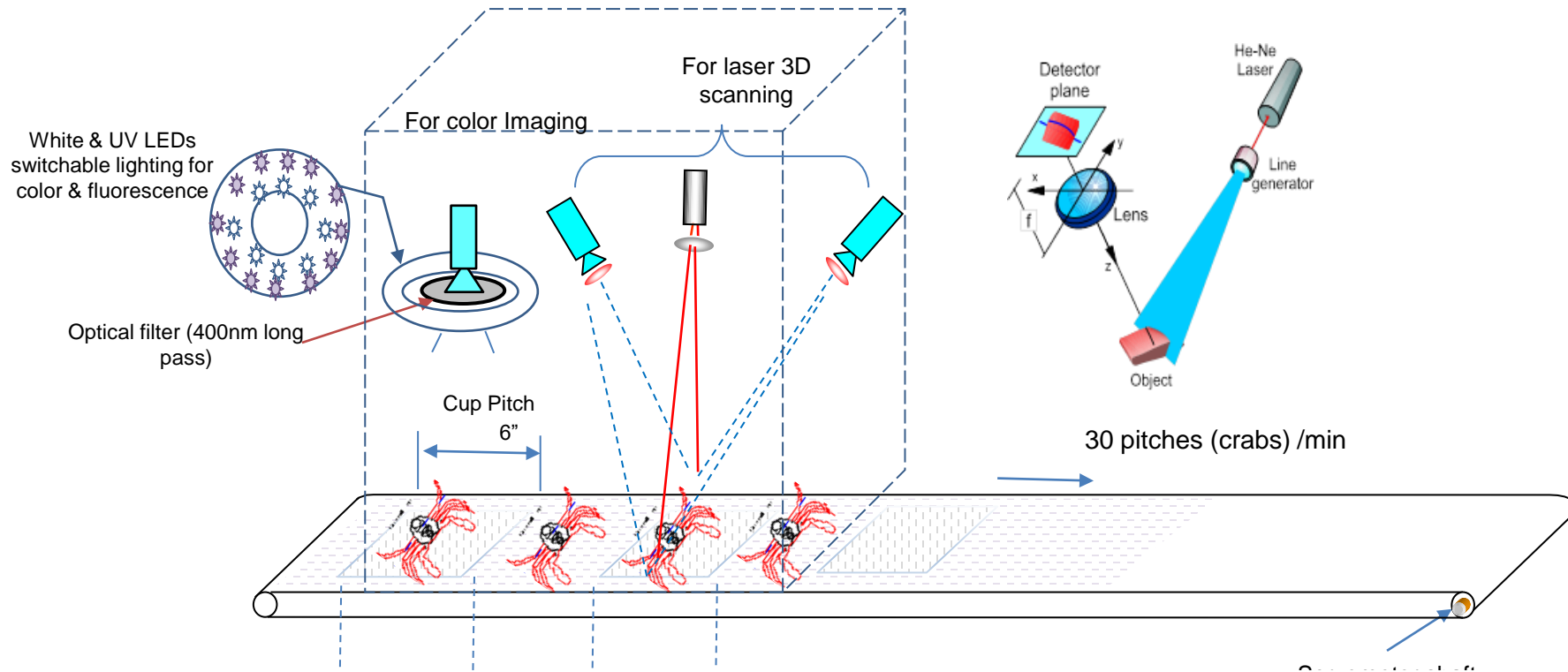
(b)

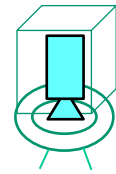
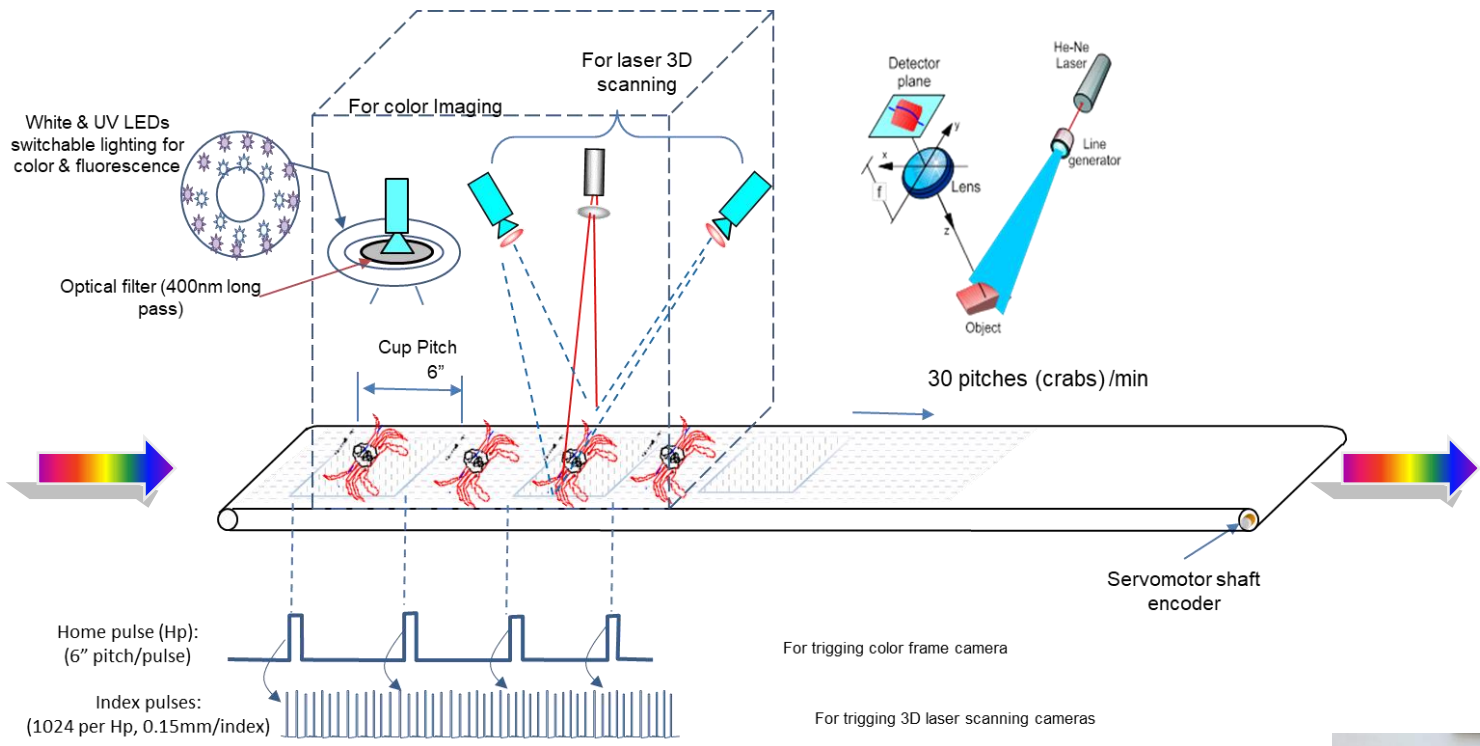


(c)

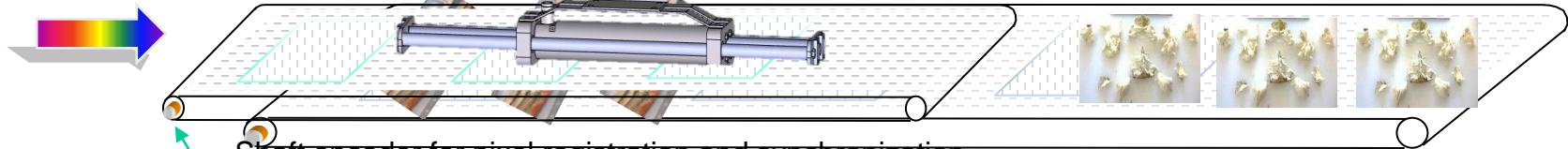
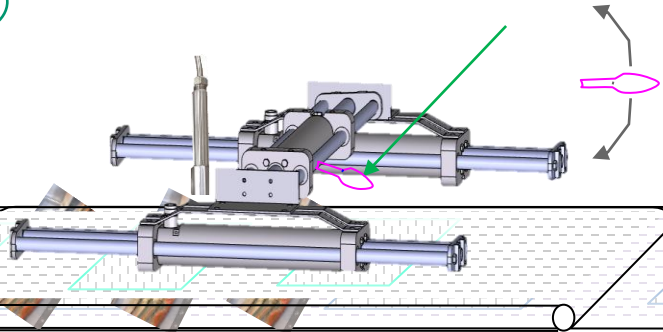


(d)





Spoon like picker

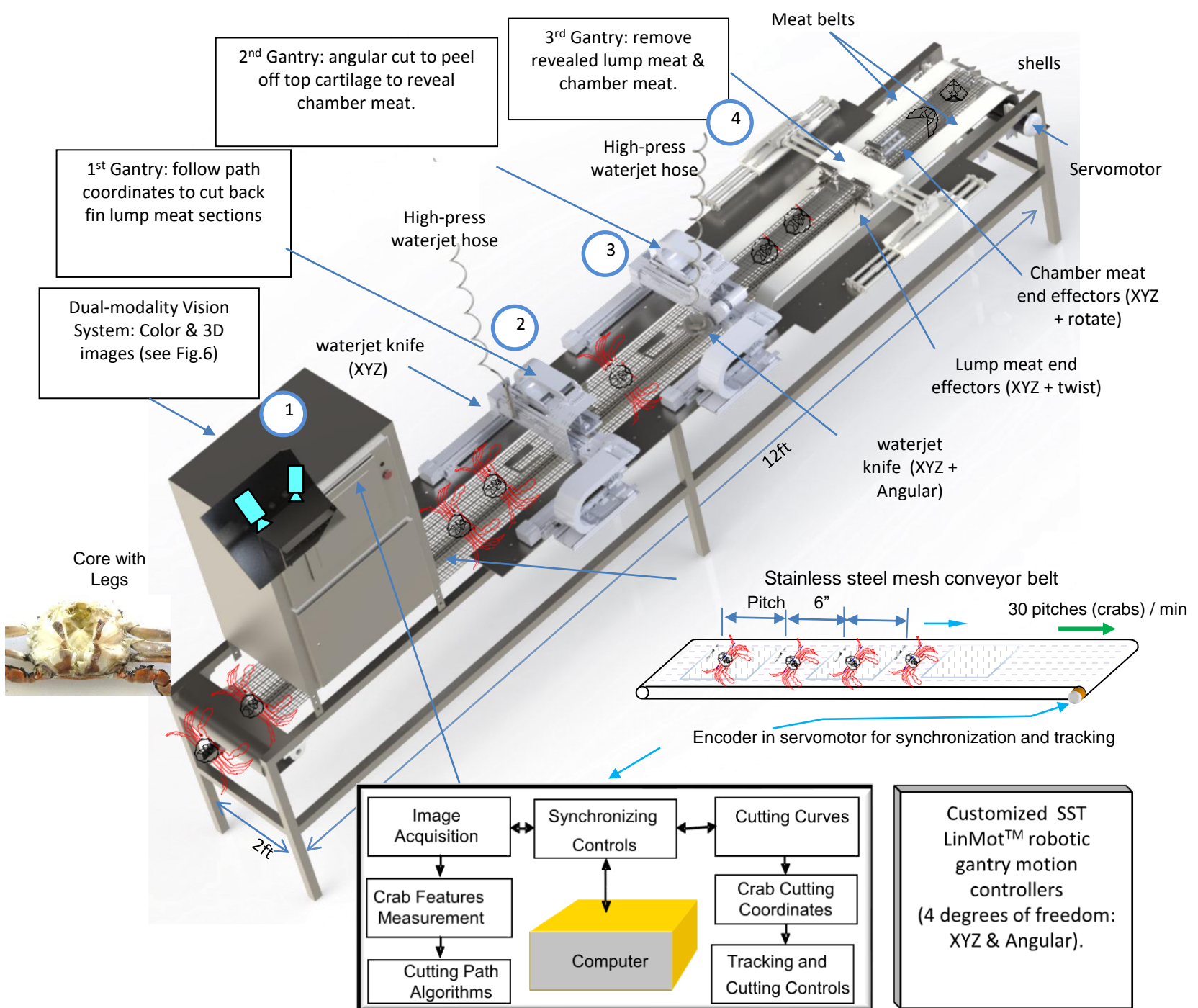


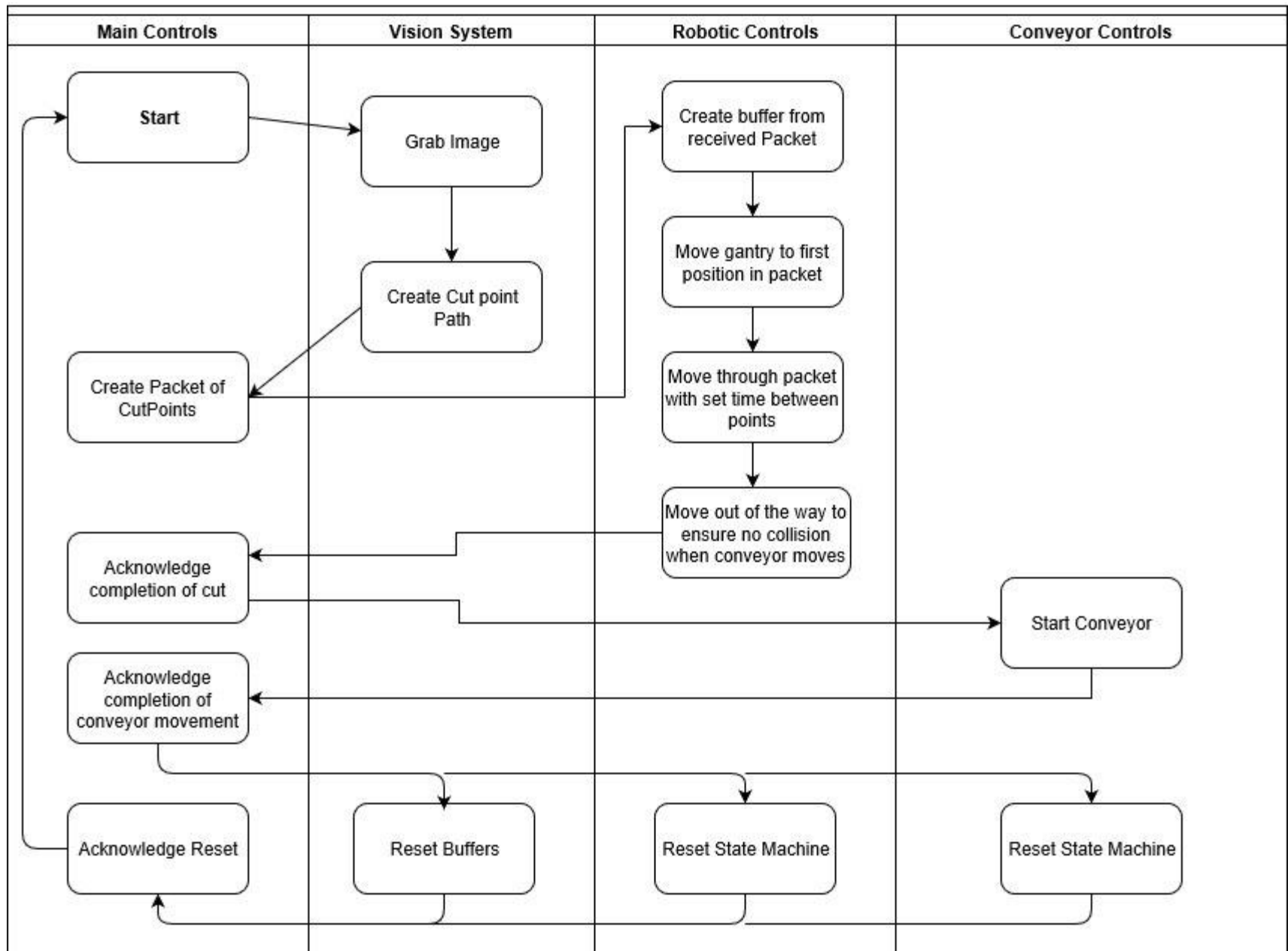
Special stainless steel crab mesh conveyer w/ shaft encoder for synchronization and pixel registration.







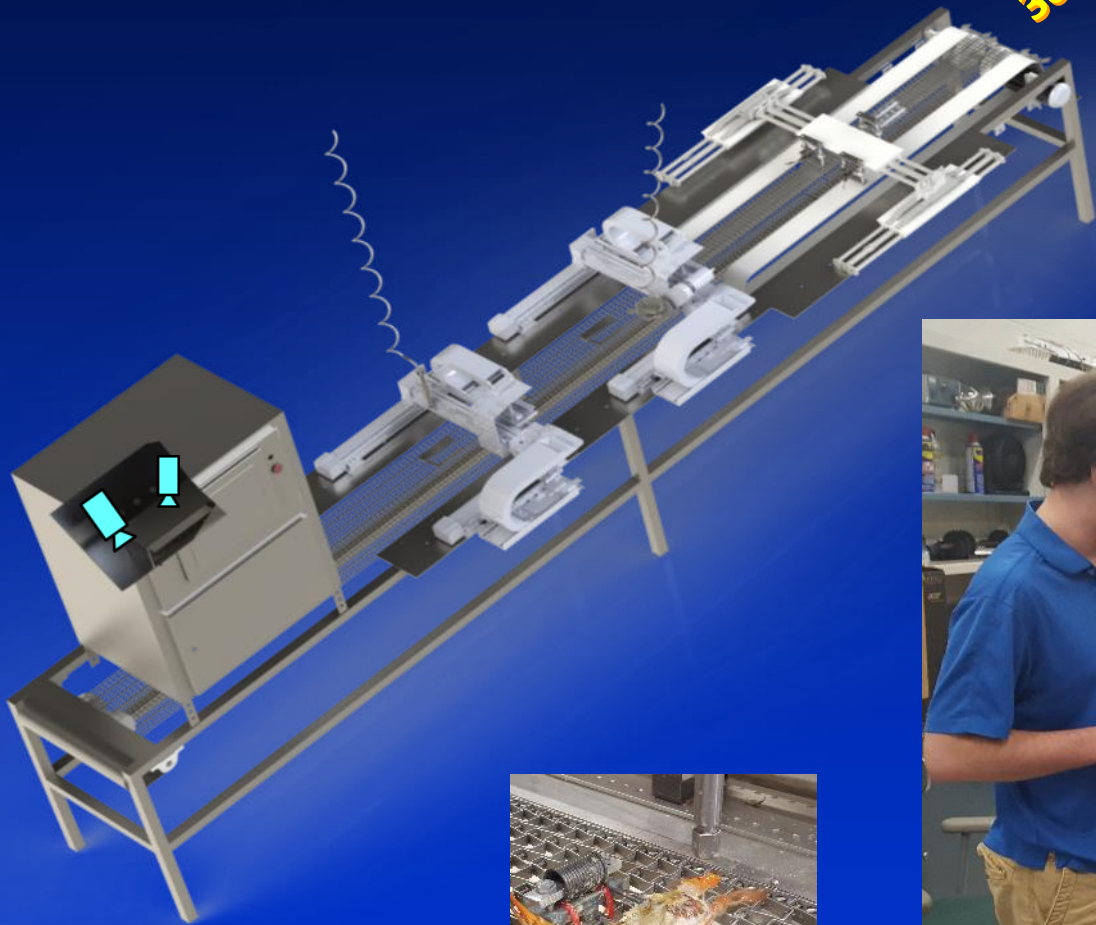




Vision-Guided Robotic System for Blue Crab Disassembly

30 crabs /min FIFO

- Enhancing food safety & productivity (15 Fold).
- Helping labor shortages



Robotic crab disassembly line (Concept, under development)

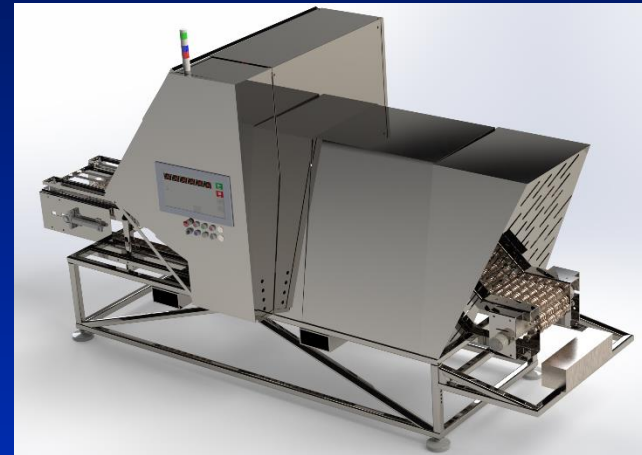
Summary

Engineering Future Foods through Vision Automation

Labor Intensive



Automation



Thank You



University of Maryland
Bio-imaging & Machine Vision Lab

ytao@umd.edu (301) 405-1189