

# Robotics in Horticulture

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# We need horticultural robots

- Horticultural tasks are arduous, expensive and it is difficult to get and retain labour
- Industrial robots are common, agricultural ones are not (except the automatic field harvester)

# Existing robotic fruit/veg pickers

- Greenhouse robots

- Pick cucumbers (45 s), mushrooms, lettuce and strawberries (10 s)
- Stationary robotic fertilizer & sprayer with moving potted plants
- None commercially viable except Romobility Youto strawberry picker (Japan)
- <http://www.youtube.com/watch?v=Fcvhtn7I2qw&feature=related>

- Orange-picking robot (Italy early 1980's)
  - 2 tonne tracked vehicle
  - telescopic arms with camera and blade mounted in the gripper
  - manually driven to start of grove
  - uses GPS way points to navigate along the grove
  - pick time 8.7 seconds (no wind), % picked unknown
  - fruit placed in bin?



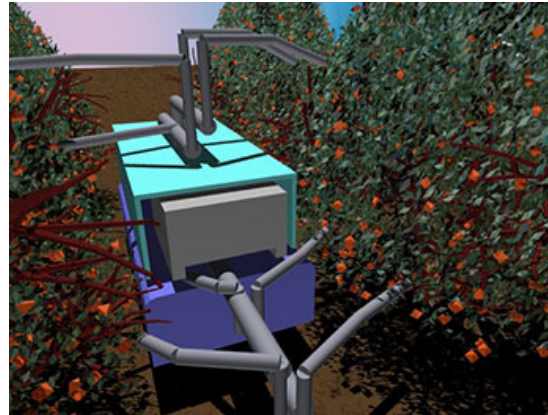
## •Apple-picking robot (Belgium, 2004)

- manually driven tractor drives Panasonic robot to tree, stabilizes robot platform, shrouds tree
- suction cup with camera at centre picks apples
- harvests 80% of apples with pick rate of 9 seconds
- manual handling of picked fruit



# Massive Financial Support

- Vision Robotics (San Diego, 2002)
  - Scout robot forms a 3D map of the location and size of fruit (oranges)
  - Picking robot with 8 arms
  - Design phase only
  - \$5M



- US Dept. of Agriculture

- \$10M funding in 2008 to Carnegie Mellon University for research into robotics for apples (\$6M) and oranges (\$4M)
- Goal: to navigate rows and recognize fruit in 3 years

# The Problems

- navigation (to the orchard, within the orchard) – GPS, intelligent computer vision
- chassis design – robust, cheap, all terrain, all weather, all tasks
- intelligent vision which makes sense of the target (fruit, trunk, etc. ) obscured by other fruit or foliage
- sophisticated design of the robot arm and end effector/gripper
- intelligent produce handling
- robot must perform many different tasks (pick, prune, bud count, pollinate, fruit count)
- general intelligence – re-fuel, load/unload bins, function autonomously (end of row, stump in the way, dirty camera, rain, light level)

# The autonomous kiwifruit picker



# Navigation

- GPS to navigate to orchard
- Computer vision to:
  - recognise poles and walk along the avenues picking
  - 3-point turn to pick both sides of the row
  - navigate around the 'dead man' at the end of the row
- Maximum speed 5km/hr

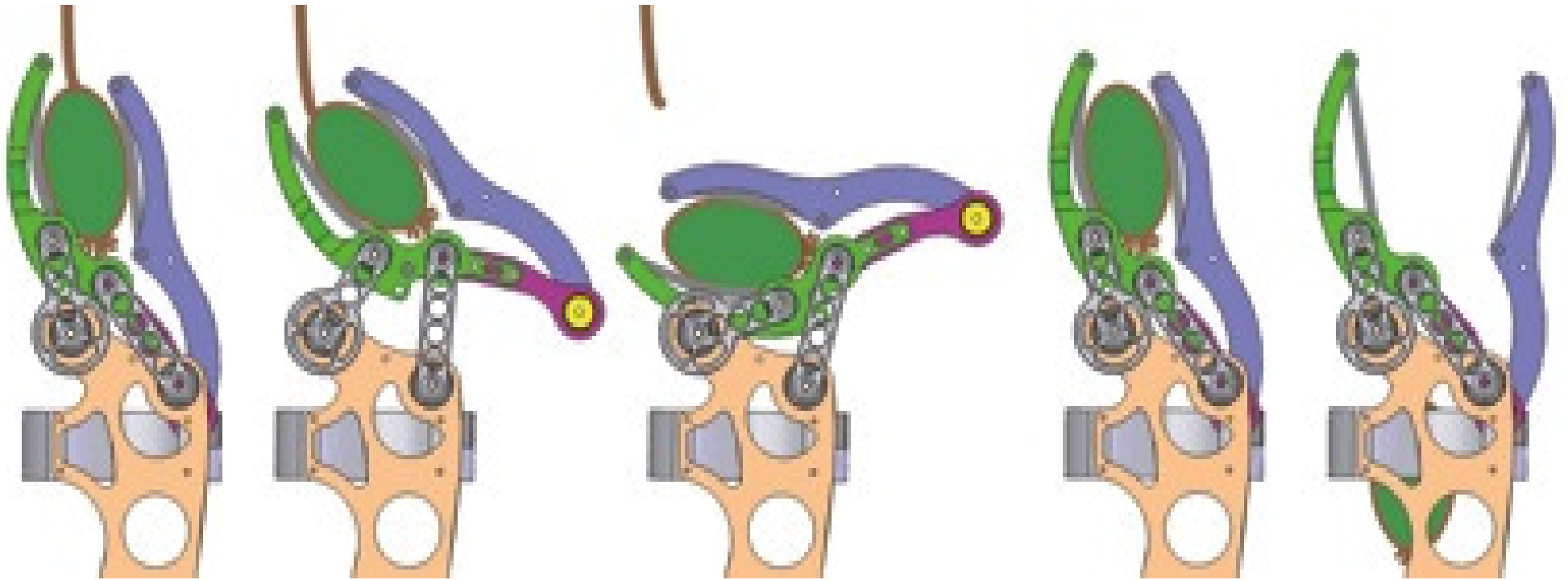


# Keeping an eye on the fruit

- 8 colour webcams, auto-iris lenses and framegrabbers look at the canopy and use stereopsis to get the coordinates of the fruit.
- 2 webcams look at the bin and map its surface height

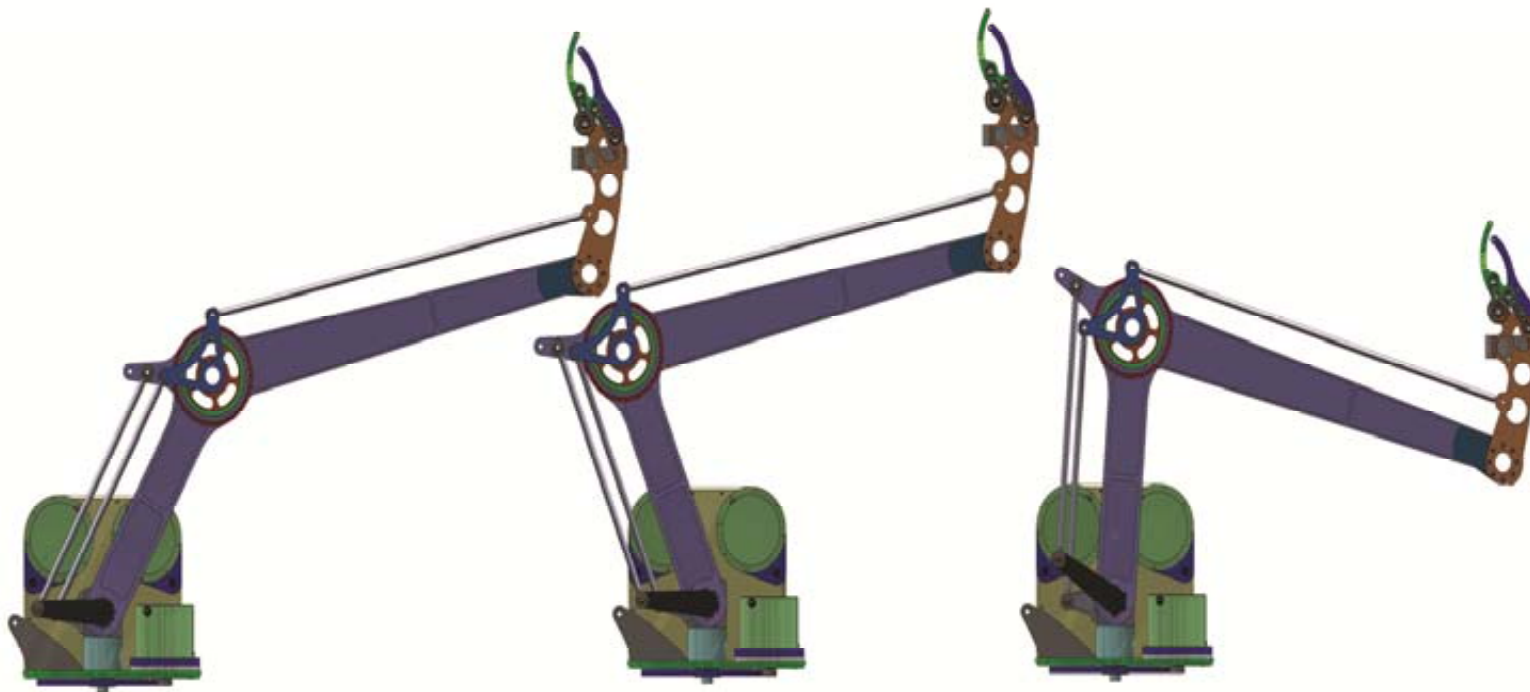


# Picking hand



# Robot arms

- Off-the-shelf robot is too expensive, too heavy and too unfriendly
- Custom-designed arms (4) are light, simple, cheap.
- Programmed to do a 'go to' move and a 'pick' move
- Pick time 1 second (each arm),  $\frac{1}{4}$  second





# The Future

- Pick for the 2010 season
- Extend intelligent vision – only pick fruit of the correct size and shape, discard defective fruit.
- Collect data on harvest rate, fruit damage, orchard yield, percentage ‘good’ fruit, etc.
- Interact with packhouse – communicate the quantity, size and quality of fruit as it is being picked. Receive instructions from the packhouse on what to pick.
- Implement other applications: pruning, pollination, bud count, fruit counts