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Advanced Robotics in Agriculture

- The role of robotic technology in the agricultural industry
  - *In what ways it the same?*
  - *What are the differences?*
- Some examples from Silsoe and around the world
- Conclusions

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Mechanisation has transformed agriculture

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Concerns over safety and environment

- Sustainable low input farming does not mean low tech farming
- A role for robotics

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Similarities between agriculture and manufacturing industry

- Intense cost pressures
- Strong foreign competition
- Difficult to find good labour
- Need to invest in technology/equipment to improve productivity
- Environmental pressure to be “clean”

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Differences between agriculture and manufacturing industry

- Huge variability in materials
  - *Plants*
  - *Animals*
  - *Growing environment, soils, lighting etc*
- Small business structure (changing)
- Often seasonal

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Some examples to illustrate the challenges

- Protected crops - *mushroom harvesting*
  - transplant, micro-propagation
- Fruit - *apple and orange harvesting*
- Field crops - *vision guidance and autonomy*
  - patch spraying
- Animals - *sheep shearing*
  - robotic milking
  - pig and fish monitoring

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Protected crops

- On the face of it the least difficult sector
- Controlled condition
- Most success has been in handling plant containers
- Limited success in handling the product directly

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Mushrooms

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Micro-propagation (ForBio Limited)

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Module transplanting (Viscon B.V)

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Fruit

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MAGALI

- French Spanish collaboration
- 1980's through 1990's but has failed on economic performance
- Novel flash technique

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Field Crops

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A vision guided hoe for inter-row cultivation and band spraying

- Drivers: economic, environmental and food safety.
- Performance.
  - *Accuracy, speed, robustness, workable hours*
- Technology.
  - *Signal processing approach to row finding*
  - *Kalman filter for row tracking*
  - *Low cost robust computing hardware*
  - *Traditional mechanics and hydraulic control*

Vision guided hoe

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Row finding

- Digital camera looking forward to side of tractor.
- Horizontal scan lines exhibit a periodic pattern in grey level.
- Bandpass filter to locate crop rows even in presence of shadow or random weeds (no threshold).

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Row tracking

- Eight horizontal scan lines each provide an observation for the Kalman filter based tracker.
- Kalman filter state vector

$$X = [x_h \; \theta \; \propto]^T$$

where: x_h = horizontal offset of hoe blades
θ= orientation of crop rows
$\propto$ = correction for camera skew

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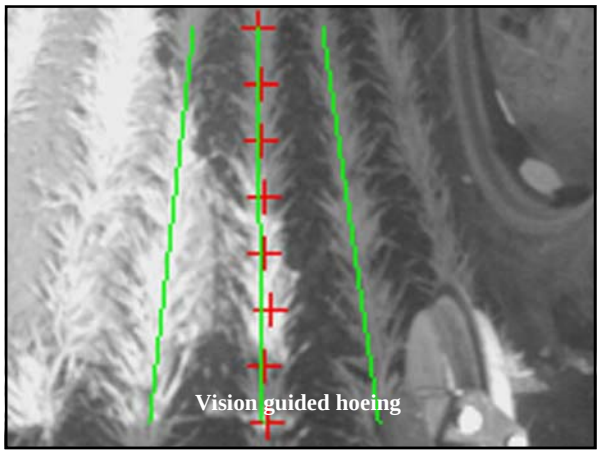

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Commercial Hoe (Garford/Robydome/SRI)

GARFORD FARM MACHINERY

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Autonomy for crop protection and data gathering vehicles?

- Safety issues are in the medium term insurmountable for high power agricultural operations
- Niche applications in spot crop protection or data gathering applications perhaps
- Technology of autonomy is very relevant to reducing driver work load
- Demonstrated autonomous vision guided navigation and spot treatment in 1996

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Results

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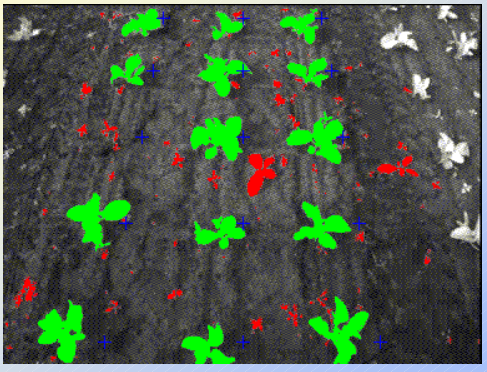

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Animals

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Marino sheep shearing

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Early robotic milking stall

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Voluntary milking system

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Teat cup attachment

Silsoe prototype system

Commercial development (DeLaval)

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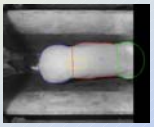
Original image



Dividing into parts (shape)

Monitoring growth

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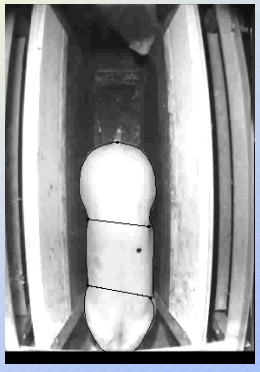
- Sensors capable of providing valuable information are available.
- Hand deployment of sensors is impractical.
- Can we predict deployment point from measurable points?



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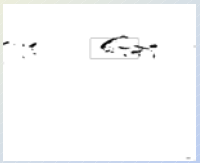
Farmed fish images



Fish head detector, leftward motion

Fitting model to individual fish

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Conclusions

- There is a need for robotics technology to meet productivity, quality and environmental aspirations
- Natural variability provides a number of technical challenges
- Require application knowledge
- Modest progress, with plenty of scope
- Evolution rather than revolution