Recognising Plants with Ultrasonic Sensing for Mobile Robot Navigation

Phillip McKerrow & Neil Harper

University of Wollongong
School of Information Technology and Computer Science
Intelligent Robotics Laboratory

Overview

- Many environments include plants
  - Harvesting
  - Landmark navigation
- Plants have a complex geometric structure
- Can be recognised with ultrasonic sensing
- Acoustic density profile model
- Plants can be used for navigation

Introduction

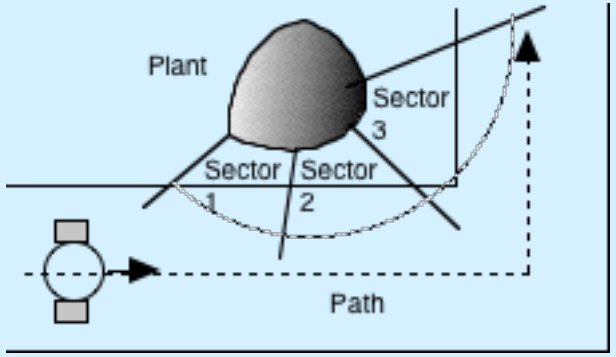
- Ultrasonic echo from a plant contains information about its geometric structure
- Plant database of 100 plants
- Problems identified
  - plant similarity
  - plant acoustic symmetry
- Feature extraction
  - Features vary less than echo spectra with rotation

Machine Recognition of Plants

- Tilling crops - detect crop row
  - Steeroids - Vision system
- Green house navigation - detect plants
  - AURORA - Ultrasonic system
- Fruit Picking - occlusion and lighting
- Selective Spraying - plant recognition
- Crop Line Tracking - image variability

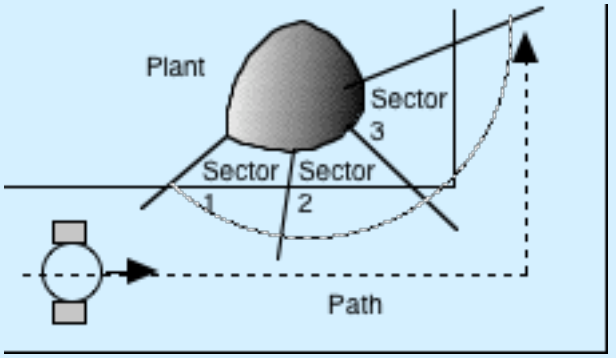
Navigation strategies

- Teach and Replay
  - Detect landmarks, store on map
- Determine expected bearing of plant
  - Point sensor in that direction
  - Bearing changes as robot moves
- Detect plant
  - Localise robot to map
  - count plants



Plant asymmetry

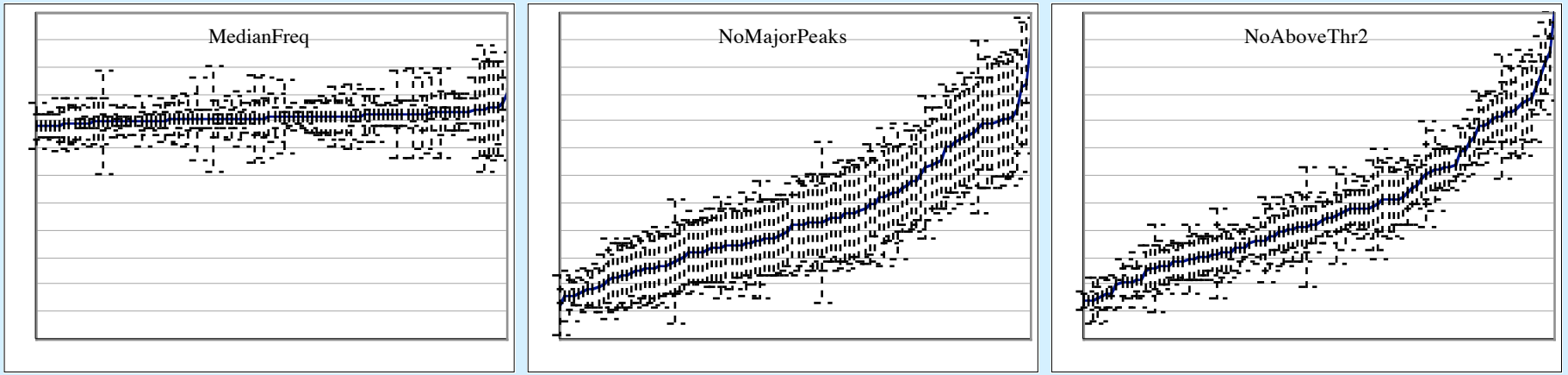
- Used to determine orientation of robot to plant
- Regions were partially symmetric
  - Use correlation to measure symmetry
- Divide plant into partially symmetric sectors
  - Record features for each sector
  - Robot tracks around plant
    - Determines orientation
      - relative to plant



Feature selection

- For robust classification want features that are:
  - Easily extracted from echo
  - Invariant with orientation
  - Represent defined geometric characteristics of plant
  - Vary between plants

poor ***Plots of feature for 100 plants*** good



Plant variation with rotation

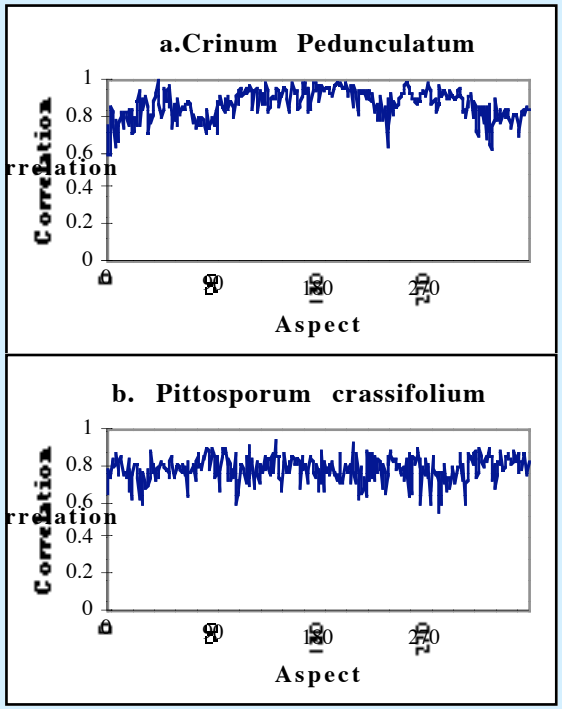
- Acoustic density profile changes
- Compare adjacent profiles
  - Variation increases with angle
  - Local correlation
    - Robot can use it to confirm it is still sensing same plant
- Compare to reference profile
  - Global correlation
    - Large angular separation between samples
    - Irregular sensing

a. Crinum peduncalutum

b. Pittosporum crassifolium

Local correlation

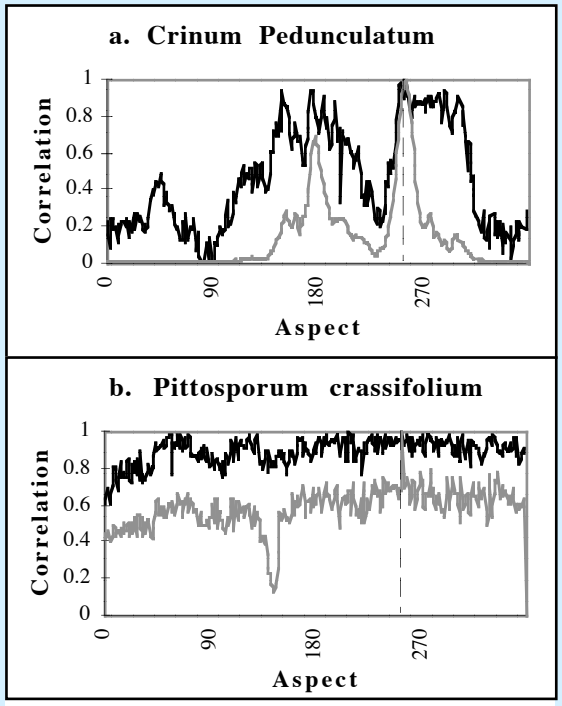
- Thick layer of outer foliage
  - More consistent with rotation
- Leaves widely spread
  - Vary substantially
- Results
  - A. 0.87 with std 0.08 -> 4/100
  - B. 0.79 with std 0.07 -> 73/100
  - Average - 0.80, max 0.9, min 0.74
  - Best - plants with few leaves
  - Worst - large number of leaves
    - Profile changes rapidly with orientation



Global correlation

- Acoustic Density Profile
  - Poor - grey graph
- Features
  - Generally good - black graph
  - Consistent with physical properties
- Better with few reflective surfaces
- Measure of
  - Global symmetry
  - Partial symmetry
  - Rate of change of symmetry

Reference profile 256º



Conclusion

- Suitability of plants for landmarks
  - depends on variation with rotation
- Correlation measures plant symmetry
- Local correlation
  - Small changes in orientation
  - High local asymmetry = good landmark
- Global correlation
  - Change through all orientations
  - Much better with features