Small Object Detection in an Outdoor, Time Varying, Dynamic Environment

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Overview of Presentation

• Introduction

• Research Techniques
  – Results and Findings

• Future Directions

• Summary
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Complex Systems
Research Problem

• To identify small objects (bees) in a video sequence in an outdoor environment

• Faced with three challenges
  – Size of the honeybee
  – Highly dynamic background
  – 3D Environment
Research Problem

• To identify small objects (bees) in a video sequence in an outdoor environment

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Research Site

• The Macadamia Tree
  – Large evergreen tree which grows in tropical climates
  – Produces the macadamia nut
  – Australia is the world’s largest producer,
    • 34,400 tonne in 2001

• Data Collection
  – Portable, CCD cameras placed in a macadamia orchard
  – Video digitized from VCR recordings
  – 320 x 240 pixel resolution @ 24 frames per second
Motivation for Research

• Little research has focused on small object detection rather the majority has focused on tracking people and vehicles

• Existing data gathering techniques were of minimal use when attempting to gather information for use in complex system modeling

• Research into an automated data collection tool for the purposes of complex system modeling
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Techniques

- Balch *et al.* (2001) used Colour Segmentation

- Colour is not a viable option in outdoors environments (Horn, 1986)

- Edges, shapes, size or texture segmentation is not a viable option
Frame Differencing Techniques in Brief

- An adaptive background model generated from 0,…,n-1 images
- Absolute Difference Subtraction
- Noise Filter
- Local Threshold
- Boundary Restoration
Frame Differencing Techniques in Brief

- An adaptive background model generated from 0, ..., n-1 images

Consider the following image sequence

Then the background model, $B_T$ is created by:

$$B_T = (1 - \alpha).B_{T-1} + \alpha \cdot I_T$$
Frame Differencing
Techniques in Brief

• **Absolute Difference Subtraction**

\[ \text{Diff}_T = |I_T - B_{T-1}| \]

• A significant amount of small difference present in the resulting images

• In the images on the left, the lighter the colour, the smaller the difference.
Frame Differencing
Techniques in Brief

- **Noise Filter**

\[ Th_x = \text{Global}_{MED} + 3 \times 1.4826 \times \text{Global}_{MAD} \]

where \( \text{Global}_{MED} \) is the median global pixel value, and \( \text{Global}_{MAD} \) is the median standard deviation

- A global approach to remove the small differences present in the images

- This technique did not erode the boundary or shape of any detected regions of difference

- However, very small high intensity noise remained
Frame Differencing Techniques in Brief

- **Local Threshold**

  \[ Th_x = \text{Global}_{MED} + NI \]

  where \( NI = \left[ \frac{\text{Global}_{MAD}}{\text{Local}_{MED}/\text{Global}_{MED}} \right] \)

  and \( \text{Local}_{Med} \) is a local median pixel value in a 3x3 grid

- A local approach to remove very small high intensity noise by adjusting the global threshold to account for local conditions

- Successfully removed isolated high intensity noise

- However, this technique eroded the boundary/shape of any regions of detected difference
Frame Differencing Techniques in Brief

• **Boundary Restoration**

  • A depth-first recursive algorithm which restores the shape of any detected regions of difference present after the local threshold is applied

  • This is achieved by using the results from the global threshold and applying it to the results after the local threshold

  • Allows the benefits of both the global and local approaches to be used without their associated problems
Frame Differencing

Results & Findings

• A very efficient technique for identifying the location of the bee

• Unable to address problems of rapid illumination change and large sustained movement of branches and flowers
Object Creation
Techniques in Brief

- A depth-first recursive search and merge algorithm is used to create objects.
- Then, spatially close objects are merged.
- Finally, objects containing less than 2 pixels are removed.
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Object Creation
Results & Findings

• By creating objects, the bees are easier to visually identify

• The minimum box was useful for estimating the size of the bee

• The movement of the flowers are detected as a series of very small objects
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Temporal Analysis
Techniques in Brief

- Two background models
  - Forwards constructed from $I_{T-11}, \ldots, I_{T-1}$
  - Backwards constructed from $I_{T+11}, \ldots, I_{T+1}$

- The resulting objects from both models are compared and objects which do not match are removed
Temporal Analysis
Results & Findings

• Very efficient for removing the differences caused by the movement of the flowers

• Excellent results at retaining and extracting the difference caused by the movement of the bee
Object Association
Techniques in Brief

- Association between objects within a maximum distance

- Euclidean Distance between all points in this distance is calculated

- The closest points in Euclidean Distance are joined by an edge and considered the same object in two separate frames
Object Association
Results & Findings

- Good at tracking a bee’s path assuming the prior conditions are met

- Also tracks the path of moving objects such as branches, which are difficult to distinguish from bees

- Can create paths from random or isolated noise
More Results
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Future Directions

- The collection of more video data to allow for further investigation and analysis of the techniques used during this research.

- Conditions, such as rain, strong wind and rapid illumination changes are commonly found in outdoor environments and will need to be studied before the development of a fully automated data collection system is practical.
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Summary

• Although further research is required to address a broad range of environmental conditions, the results obtained so far, have proven that small object detection is a feasible technique for addressing the current problems of data collection.

• Published Work Arising from this Research
Questions?