Streamlining the Analysis of Accelerometry Data to Improve Understanding of Animal Behaviour

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Overview

- Background
- System Objectives
- System Architecture
- Software User Interface
- Evaluation
  - Data collection
  - Evaluation Result
- Summary
- Future work
Background: Accelerometry Data

- Explosion in animal-attached accelerometers
  - To monitor animal movements and behaviour
- Collected an avalanche of raw tri-axial accelerometer data streams
  - Enable the identification of specific animals' behaviours

Animal ecologists

Used

Tri-axial accelerometers

Deployed on

Endangered Species

Pests

Production livestock

Animal accelerometry Data
Background: Accelerometry Data

**Step 1** Collect data

**Step 2** Analyse data

- running
- walking
- resting
- walking
- running
- feeding
- walking

**Step 3** Visualization

Understand animal health, energy consumption, food/water requirements
Background: Accelerometry Data

**Step 1**
Collect data

**Step 2**
Analyse data

- running
- walking
- resting
- walking
- running
- feeding
- walking

**Step 3** – Visualization

Understand animal health, energy consumption, food/water requirements
Limitations of raw 3D accelerometry data streams
- Numerical, unstructured, complex, imprecise, large volume
- Poor data representation

Problems
- Massive volumes of complex data
- No common markup
- Lack of automatic analysis
- Lack of pattern recognition tools
- Manual analysis
  - Onerous, time consuming, expensive
  - Poor quality, subjective

Wild animal activities
- Difficult to monitor and analyze

Background: Challenges

How to analyze???
How to improve???

What is 87???
What is the measurement unit??

A  B  C  D  E  F  G
1  07.06.37 18:00:00  87.361  14.06.87 12:  
2  07.06.37 19:00:09  88.941  14.06.87 12:  
3  07.06.37 19:00:49  87.541  14.06.87 12:  
4  07.06.37 19:00:27  87.541  14.06.87 12:  
5  07.06.37 19:00:36  88.941  14.06.87 12:  
6  07.06.37 19:00:45  87.361  14.06.87 12:  
7  07.06.37 19:00:54  87.541  14.06.87 12:  
8  07.06.37 19:01:03  87.541  14.06.87 12:  
9  07.06.37 19:01:12  87.541  14.06.87 12:  
10  07.06.37 19:01:21  87.361  14.06.87 12:  
11  07.06.37 19:01:30  87.541  14.06.87 12:  

System objectives

1. Web-based repository
   - To upload and share
   - To search and retrieve
     tri-axial accelerometry animal datasets

2. Annotation services
   - visualize 3D accelerometry datasets and videos
   - Synchronized with video to compare with ground truth
   - Record, share and re-use expert knowledge
   - Using terms from pre-defined ontologies

3. Automated analysis services
   - Build activity recognition models
     - Species-specific classifier and cross species classifier

4. Simple statistical visualizations
   - understand the activity recognition results
System Architecture

SAAR – Semantic Annotation and Activity Recognition System
Screenshot of the SAAR upload user interface
Screenshot of SAAR Plot-Video visualization interface and the annotation interface
User interface when retrieving all the specific annotation to train a SVM activity classifier
Screenshot of the SAAR interface with human activity identification results
Evaluation - Data Collection

- Device: G6A
- 8 voluntary students & staffs
  - 4 males & 4 females
- 6 domestic dogs
- 3 badgers
Evaluation-Metrics

- Standard evaluation metrics
  - Accuracy
    \[ \text{Accuracy} = \frac{\text{number of true positives} + \text{number of true negatives}}{\text{number of true positives} + \text{false positives} + \text{true negatives} + \text{true negatives}} \]
  - Precision
    \[ \text{Precision} = \frac{\text{number of true positives}}{\text{number of true positives} + \text{false positives}} \]
  - Sensitivity
    \[ \text{Sensitivity} = \frac{\text{number of true positives}}{\text{number of true positives} + \text{false negatives}} \]
  - Specificity
    \[ \text{Specificity} = \frac{\text{number of true negatives}}{\text{number of true negatives} + \text{false negatives}} \]

<table>
<thead>
<tr>
<th>Test outcome</th>
<th>Type as determined by a classifier</th>
</tr>
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<tbody>
<tr>
<td>+ve</td>
<td>True positive</td>
</tr>
<tr>
<td>-ve</td>
<td>False negative</td>
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<table>
<thead>
<tr>
<th></th>
<th>False</th>
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<tbody>
<tr>
<td>True positive</td>
<td>False positive</td>
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<tr>
<td>False negative</td>
<td>True negative</td>
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Evaluation-Result-1

Humans

Dogs
Evaluation-Result 2

Badger data, dog model
Evaluation - Conclusions

- High level classifiers performs better than low level classifiers
  - High level: accuracy > 96%, sensitivity > 97%, specificity > 96%
  - Low level: accuracy > 96%, sensitivity > 80%, precision > 80%
- Human classifier performs better than dog classifier which performs better than badger classifier
  - More noise the “wilder” the animals
- Species-specific classification models perform better than migrating the classification models across species, but migration still yields reasonable results
Summary

- The Semantic Annotation and Activity Recognitions system delivers
  - An easy-to-use Web-based repository
    - For accelerometer data streams
  - A set of semantic tagging, visualization services
    - For annotation meaning of accelerometer data streams
  - Activity recognition services
    - Accuracy decreases for more “unpredictable” animals
    - Accuracy decreases across species
    - BUT still very useful
Future work

- Integrate GPS data to track animal trajectory + add map visualization
- Apply captive models to wild animals
  - Dogs to dingoes
  - Birds to bats
  - Horses to camels
- Improve model accuracy
  - Evaluate different machine learning methods
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Questions?

- Thank you!
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