

Combining Semantic Tagging and Support Vector Machines to Streamline the Analysis of Animal Accelerometry Data



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<http://oztrack.org>



Tracking cassowaries in Moresby
▶ Range National Park using GPS-based telemetry

▼ Home Range Calculator

Date Range:
From:
To:

Layer Type:

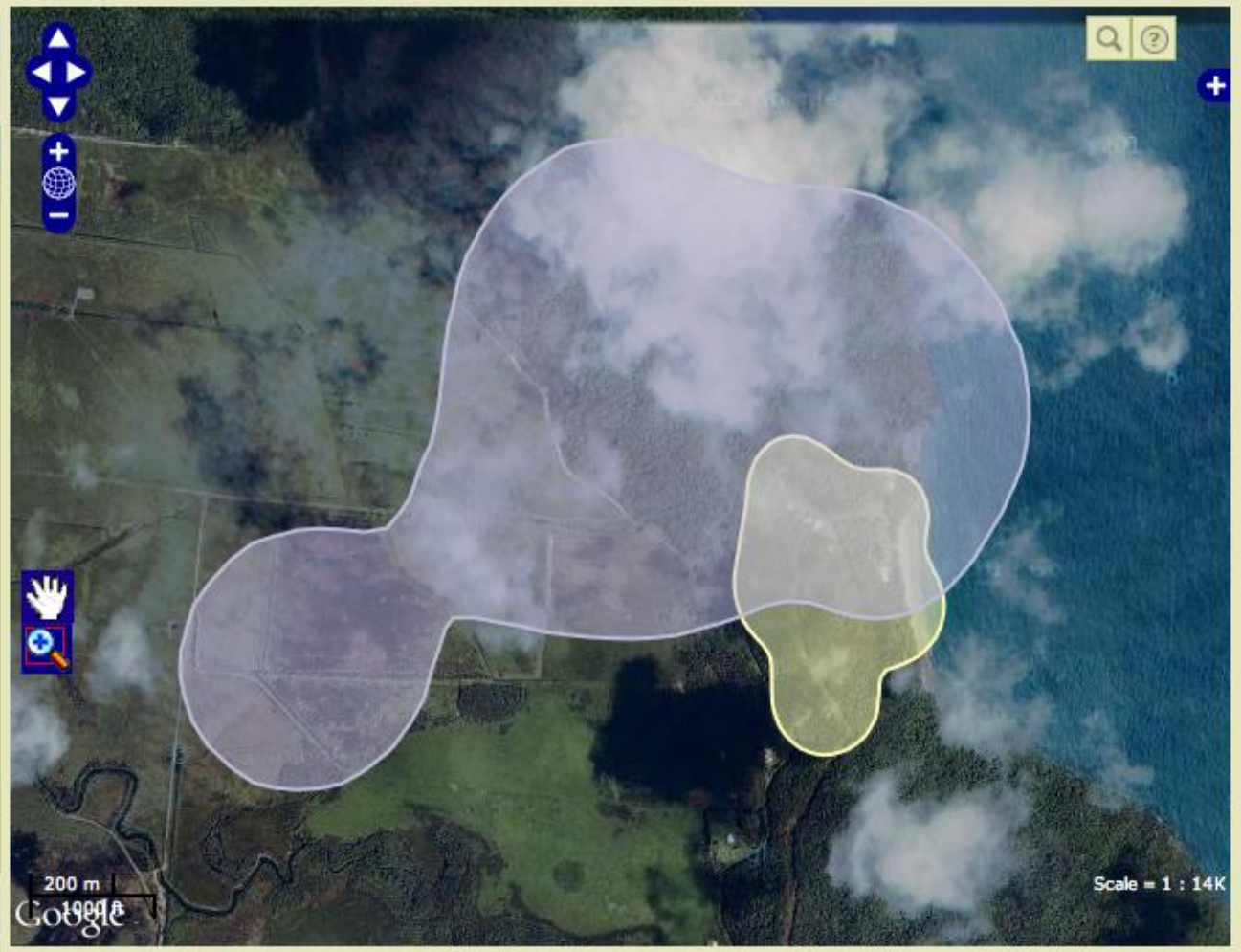
- Detections
- Trajectory
- Minimum Convex Polygon
- Peeled Convex Hull (95%)
- Peeled Convex Hull (50%)
- Kernel UD (utilization distribution) 95%
- Kernel UD (utilization distribution) 50%

Spatial Reference System:
 [Find](#) [See List](#)
EPSG:20355
Ellipse Name: Australian Natl & S. Amer. 1969

Calculate

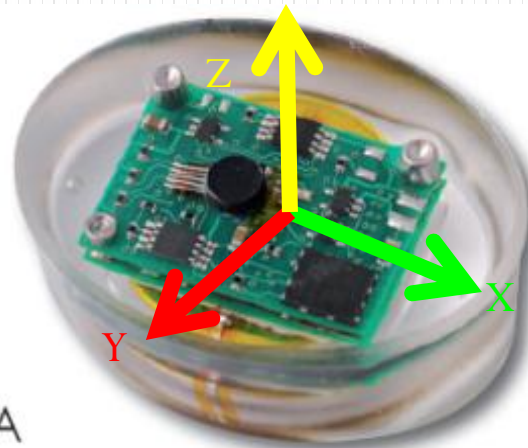
▶ Help

▶ Project Menu



Combining Semantic
Machines to Strengthen
Acc

G6A



Vector
Animal



Lianli Gao¹, Hamish Campbell², Craig Franklin², Jane Hunter¹

¹eResearch Lab, The University of Queensland, Brisbane, Australia

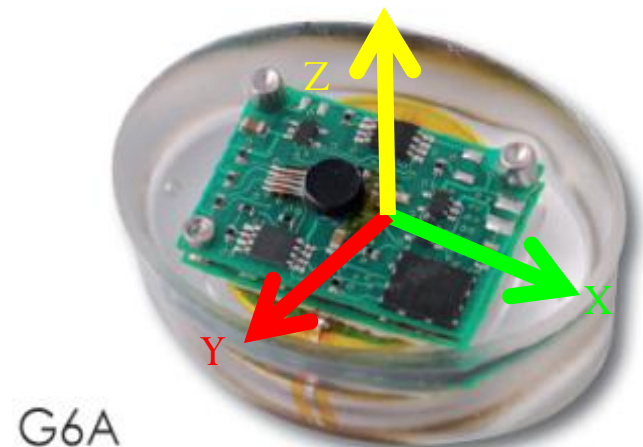
²ECO-Lab, The University of Queensland, Brisbane, Australia

Overview

- Background
- Objectives
- Methodology
 - System Architecture
 - User Interface
 - Data Collection
 - Evaluation Result
- Conclusions & Future work

Data Collection-Device

- Devices parameters
 - A tri-axial accelerometer named G6A
 - Produced by CTL(Cefas Technology Limited)
 - 40mm*28mm*16.3mm
 - 16MB memory
 - 7.3g weight in air
 - Sampling rates
 - From 1Hz to 30Hz



Background: accelerometer data

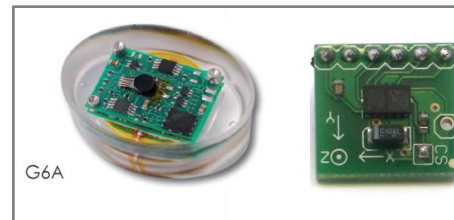
- Explosion in animal-attached accelerometers
 - To monitor animal movements and behaviour
- Collected an avalanche of raw tri-axial accelerometer data streams
 - Enable the identification of specific animals behaviours

Animal ecologists



Used

Tri-axial accelerometers



Collected

Deployed on



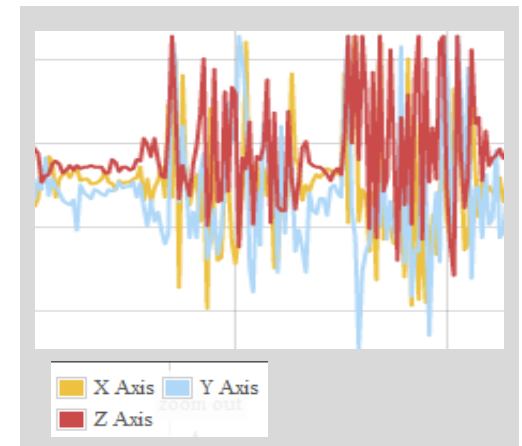
Endangered Species



Pests



Production livestock

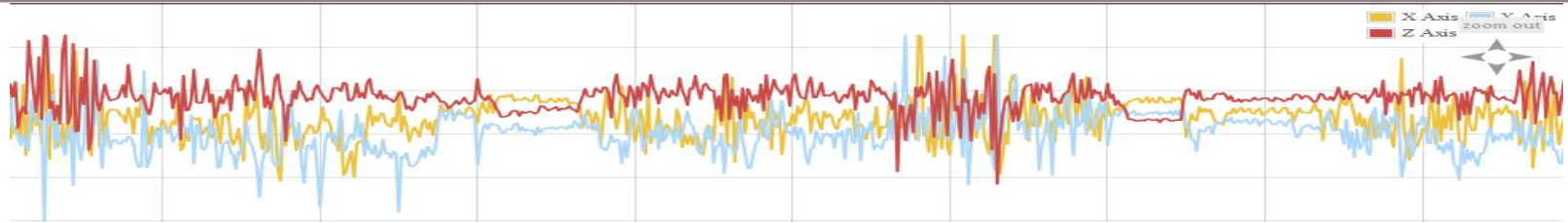


Animal accelerometry Data

Background: accelerometer data

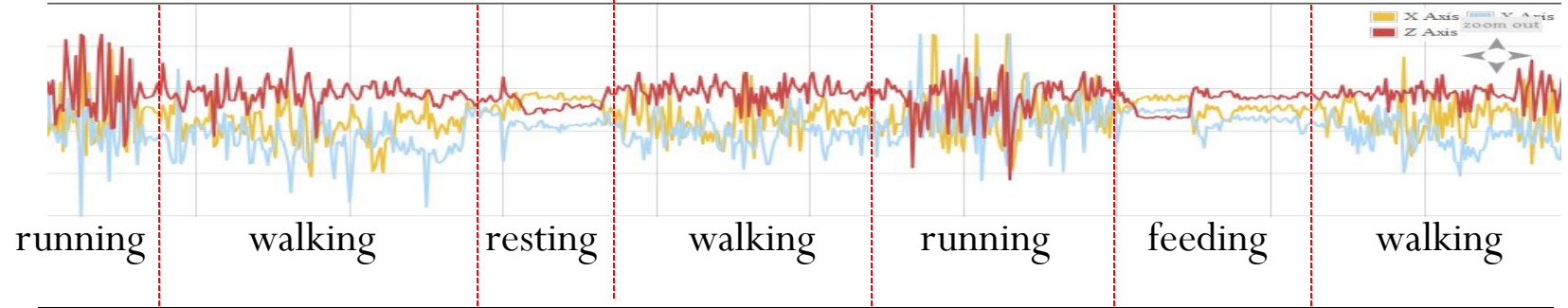
Step 1

Collect data

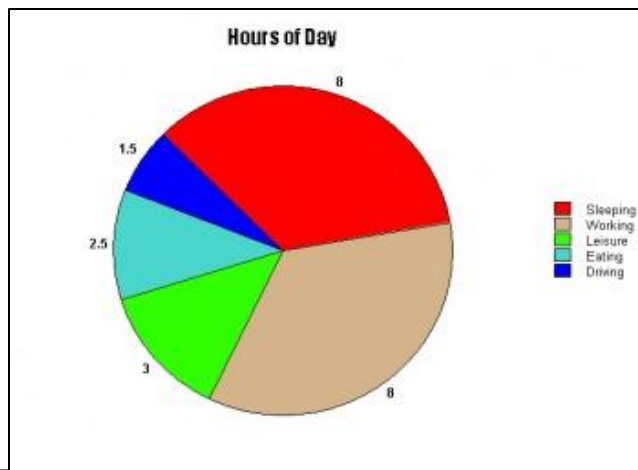


Step 2

Analyse data



Step 3 – Visualization

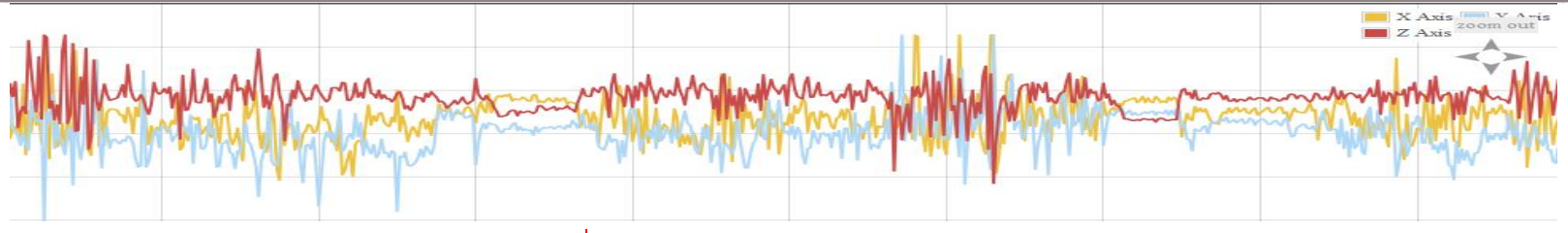


Understand animal health, energy consumption, food/water requirements

Background: accelerometer data

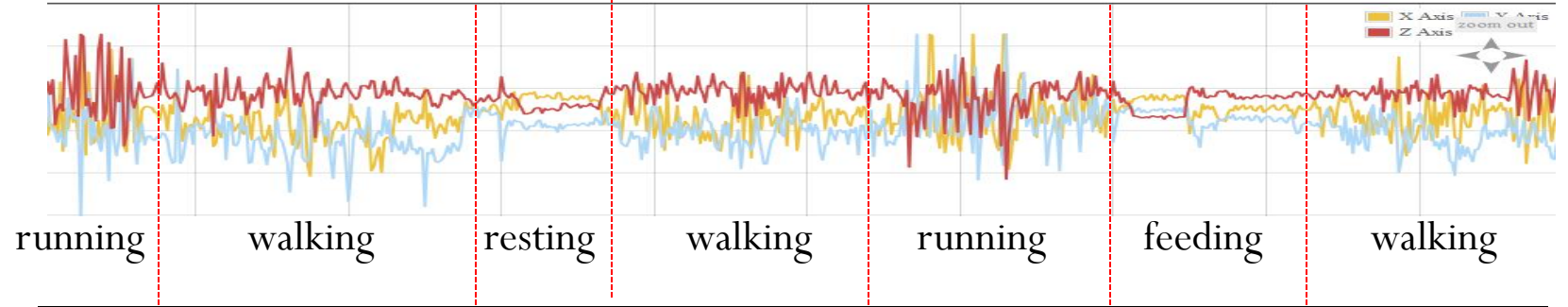
Step 1

Collect data

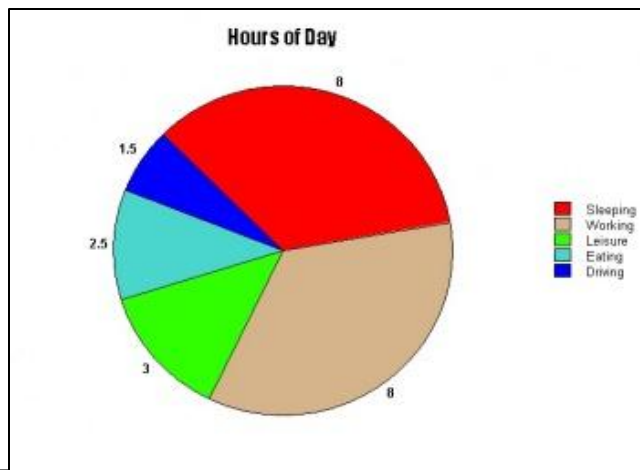


Step 2

Analyse data



Step 3 – Visualization



Understand animal health, energy consumption, food/water requirements

Background: challenges

- Limitations of raw 3D accelerometry data streams
 - Numerical, unstructured, complex, imprecise, large volume
 - Poor data representation
- Problems
 - Massive volumes of complex data
 - 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

What is 87???

What is the measurement unit??

	A	B	C	D	E	F	G
1	07.06.07 19:00:00	---	87.001		14.06.07 13:---	---	85.001
2	07.06.07 19:00:09	---	86.001		14.06.07 13:---	---	85.001
3	07.06.07 19:00:18	---	87.001	?	14.06.07 13:---	---	85.001
4	07.06.07 19:00:27	---	87.001		14.06.07 13:---	---	85.001
5	07.06.07 19:00:36	---	89.001		14.06.07 13:---	---	85.001
6	07.06.07 19:00:45	---	87.001		14.06.07 13:---	---	83.001
7	07.06.07 19:00:54	---	87.001		14.06.07 13:---	---	85.001
8	07.06.07 19:01:03	---	87.001		14.06.07 13:---	---	85.001
9	07.06.07 19:01:12	---	87.001		14.06.07 13:---	---	85.001
10	07.06.07 19:01:21	---	87.001		14.06.07 13:---	---	83.001
11	07.06.07 19:01:30	---	87.001		14.06.07 13:---	---	83.001

How to analyze???

How to improve???



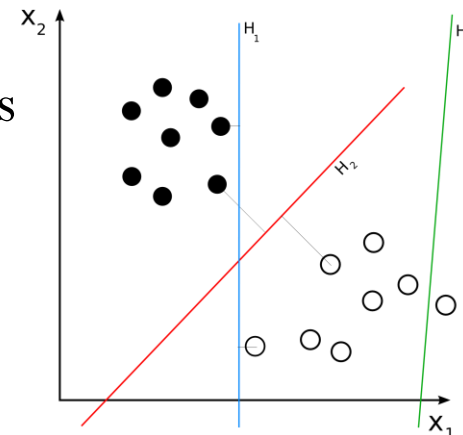
Possible solutions

- Semantic Tagging
 - attach meaningful descriptions
 - mark up events/activities
 - enrich data semantic meaning
 - collect expert domain knowledge

	A	B	C	D	E	F	G
1	07.06.07 19:00:00	---	87.001		14.06.07 13:---	---	85.001
2	07.06.07 19:00:09	---	86.001	?	14.06.07 13:---	---	85.001
3	07.06.07 19:00:18	---	87.001	?	14.06.07 13:---	---	85.001
4	07.06.07 19:00:27	---	87.001		14.06.07 13:---	---	85.001
5	07.06.07 19:00:36	---	89.001		14.06.07 13:---	---	85.001
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7	07.06.07 19:00:54	---	87.001		14.06.07 13:---	---	85.001
8	07.06.07 19:01:03	---	87.001		14.06.07 13:---	---	85.001
9	07.06.07 19:01:12	---	87.001		14.06.07 13:---	---	85.001
10	07.06.07 19:01:21	---	87.001		14.06.07 13:---	---	83.001
11	07.06.07 19:01:30	---	87.001		14.06.07 13:---	---	83.001

```
<Observation>
  <observes>x-axis acceleration</observes>
  <unit>m/s</unit>
  <hasLocation>Brisbane</hasLocation>
  <hasValue>87.001</hasValue>
  <hasTime>2007-06-07T19:00:54</hasTime>
</Observation>
```

- Support Vector Machines
 - supervised machine learning models
 - support automatic classification



System objectives

- Web-based repository
 - To upload and share tri-axial accelerometer animal datasets
 - To search, retrieve and compare datasets
- Annotation services
 - Record, share and re-use expert knowledge on animal movements within tri-axial accelerometer data streams
 - Using terms from pre-defined ontologies
 - Analyze, tag and visualize 3D accelerometry datasets
 - Synchronized with video to compare with base truth
- Automated analysis services
 - Build activity recognition models by training classifiers using features extracted from pre-annotated training sets
 - To improve the quality of results generated by SVM-based activity recognition classifier
 - To enable the sharing, re-use and refinement of activity recognition classifiers developed for specific species, between scientists.
- Simple statistical visualisation of annotated data streams

SAAR Application

seas.metadata.net/saar/

SAAR

Semantic Annotation & Activity Recognition



Search | **Upload**

Upload Files

Creator:
 e.g., Hamish Campbell

DateCaptured Start:
 e.g., mm/dd/year 03/24/2012

DateCaptured End:
 e.g., mm/dd/year 04/24/2012

Species:
 e.g., dog

Location:
 e.g., The University of Queensland

Coordinates:
lat: long: e.g.,
-27.497854,153.013286

Animal ID:
 e.g., dog1

Description:

e.g., Triaxial accelerometry data...

Upload Sensor Data

Open File: No file chosen

File List

Data: jackietrain.csv Video: jackieTrain.oqv upload by: Juana
Data: jackietest.csv Video: jackieTest.oqv upload by: Juana
Data: germanPointerTrain.csv Video: germanPointerTrain.oqv upload by: Hamish Campbell
Data: germanPointerTest.csv Video: germanPointerTest.oqv upload by: Hamish Campbell
Data: cockerSpanielTrain.CSV Video: cockerSpanielTrain.oqv upload by: Hamish Campbell
Data: cockerSpanielTest.CSV Video: cockerSpanielTest.oqv upload by: Hamish Campbell
Data: staffieCrossLabTrain.csv Video: null upload by: Hamish Campbell
Data: staffieCrossLabTest.csv Video: staffieCrossLabTest.oqv upload by: Hamish Campbell
Data: dackshuntTrain.CSV Video: dackshuntTrain.oqv upload by: Hamish Campbell
Data: dackshuntTest.CSV Video: dackshuntTest.oqv upload by: Hamish Campbell

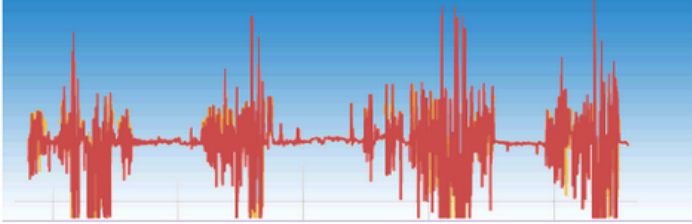

Screenshot of the SAAR upload user interface

SAAR Application

seas.metadata.net/saar/

SAAR

Semantic Annotation & Activity Recognition



Search | **Upload**

Search Options

Creator:
 e.g., Hamish Campbell

Date Captured Start:
 e.g., mm/dd/year 03/24/2012

Date Captured End:
 e.g., mm/dd/year 03/24/2012

Species:
 e.g., dog

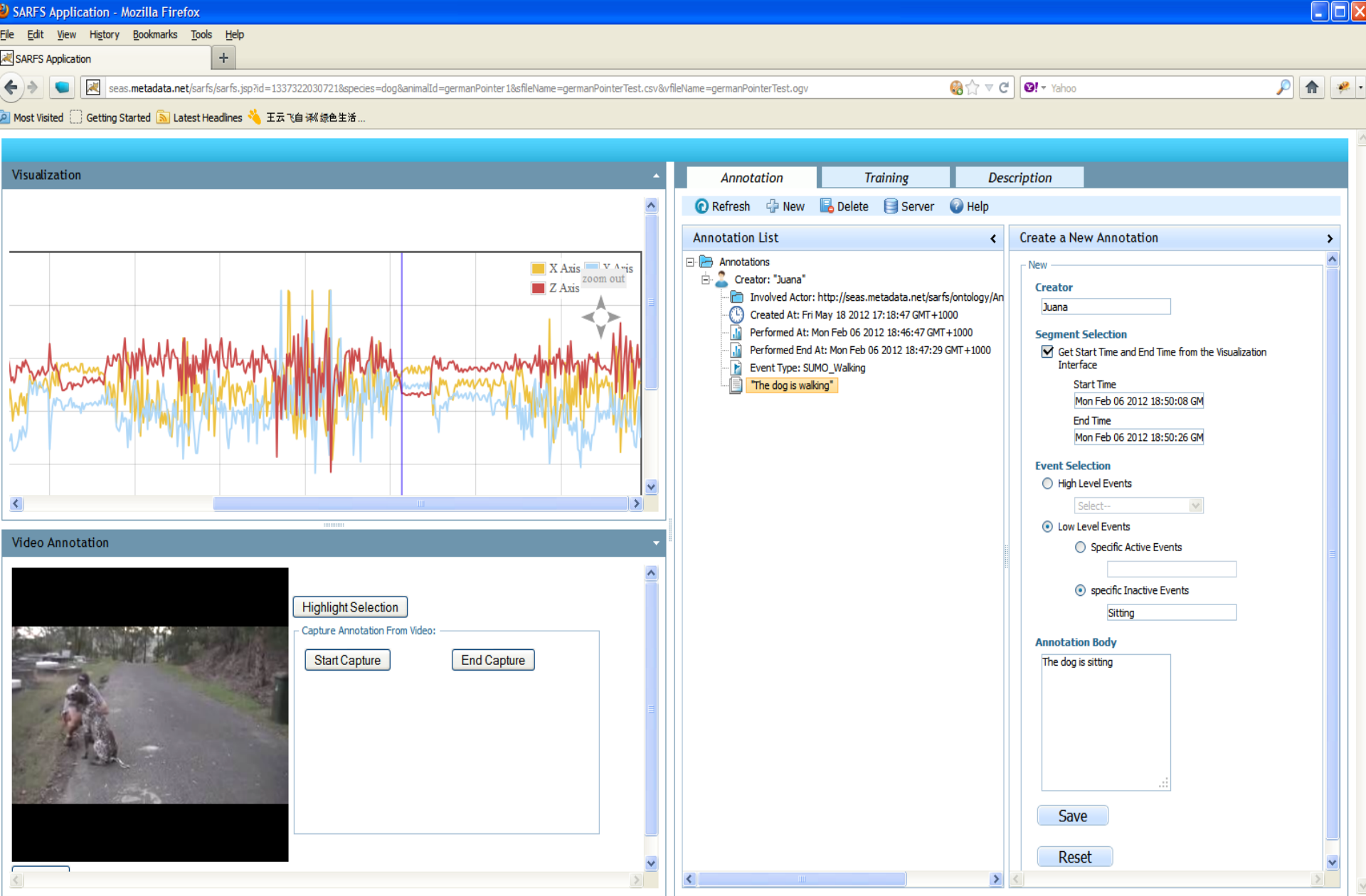
Location:
 e.g., The University of Queensland

Animal ID:
 e.g., dog1

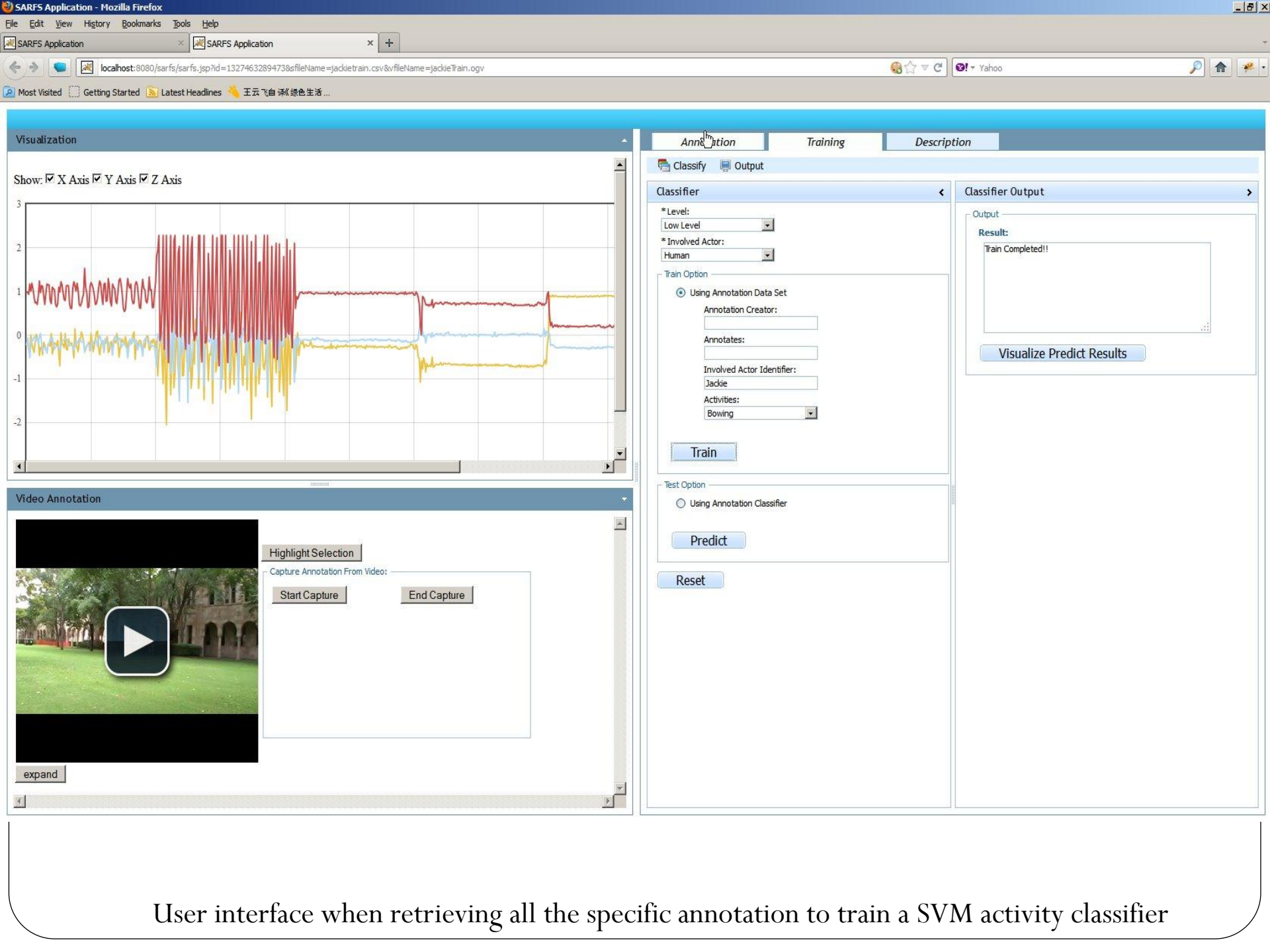
File List

- [Data: jackietrain.csv](#) [Video: jackieTrain.oqv](#)
upload by: Juana
- [Data: jackietest.csv](#) [Video: jackieTest.oqv](#)
upload by: Juana
- [Data: germanPointerTrain.csv](#) [Video: germanPointerTrain.oqv](#)
upload by: Hamish Campbell
- [Data: germanPointerTest.csv](#) [Video: germanPointerTest.oqv](#)
upload by: Hamish Campbell
- [Data: cockerSpanielTrain.CSV](#) [Video: cockerspanielTrain.oqv](#)
upload by: Hamish Campbell
- [Data: cockerSpanielTest.CSV](#) [Video: cockerspanielTest.oqv](#)
upload by: Hamish Campbell
- [Data: staffieCrossLabTrain.csv](#) [Video: null](#)
upload by: Hamish Campbell
- [Data: staffieCrossLabTest.csv](#) [Video: staffieCrossLabTest.oqv](#)
upload by: Hamish Campbell
- [Data: dackshuntTrain.CSV](#) [Video: dackshuntTrain.oqv](#)
upload by: Hamish Campbell
- [Data: dackshuntTest.CSV](#) [Video: dackshuntTest.oqv](#)
upload by: Hamish Campbell

Screenshot of the SAAR search 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

Edit View History Bookmarks Tools Help
 SARFS Application SARFS Application
 localhost:8080/sarfs/sarfs.jsp?id=1327463289473&fileName=jackieTrain.csv&vfileName=jackieTrain.ogv
 Most Visited Getting Started Latest Headlines 王云飞自谈绿色生活...

Visualization

Z Axis

Walking, 93.4% Running, 100% Standing, 94.5% Sitting, 92.7% Lying, 93.7% Sit-Ups, Running

X Axis Y Axis Z Axis

Annotation Training Description

Description

Show Statistical Results Filtered Statistical Results Filter Options

- Running
- Walking
- Sit-Ups
- Lying
- Standing
- Sitting

114,114,114,114,0,1 19.5% 132,26,26,94,40,5

108,108,108,108,0,1 16% 18.9%

120,120,120,120,0,1 17.7% 11.1%

128,26,26,120,53,5 75,15,15,64,27,5

16.8%

Label order: TT,MT,MinT,MaxT,SD,No
 MT: average duration time of a corresponding event
 MinT: minimum duration time of a corresponding event
 MaxT: maximum duration time of a corresponding event
 TT: total time spent by a corresponding event in the entire duration
 SD: standard deviation of the duration time of a corresponding event
 No: total number of a corresponding event happened in the entire duration

Video Annotation

Highlight Selection

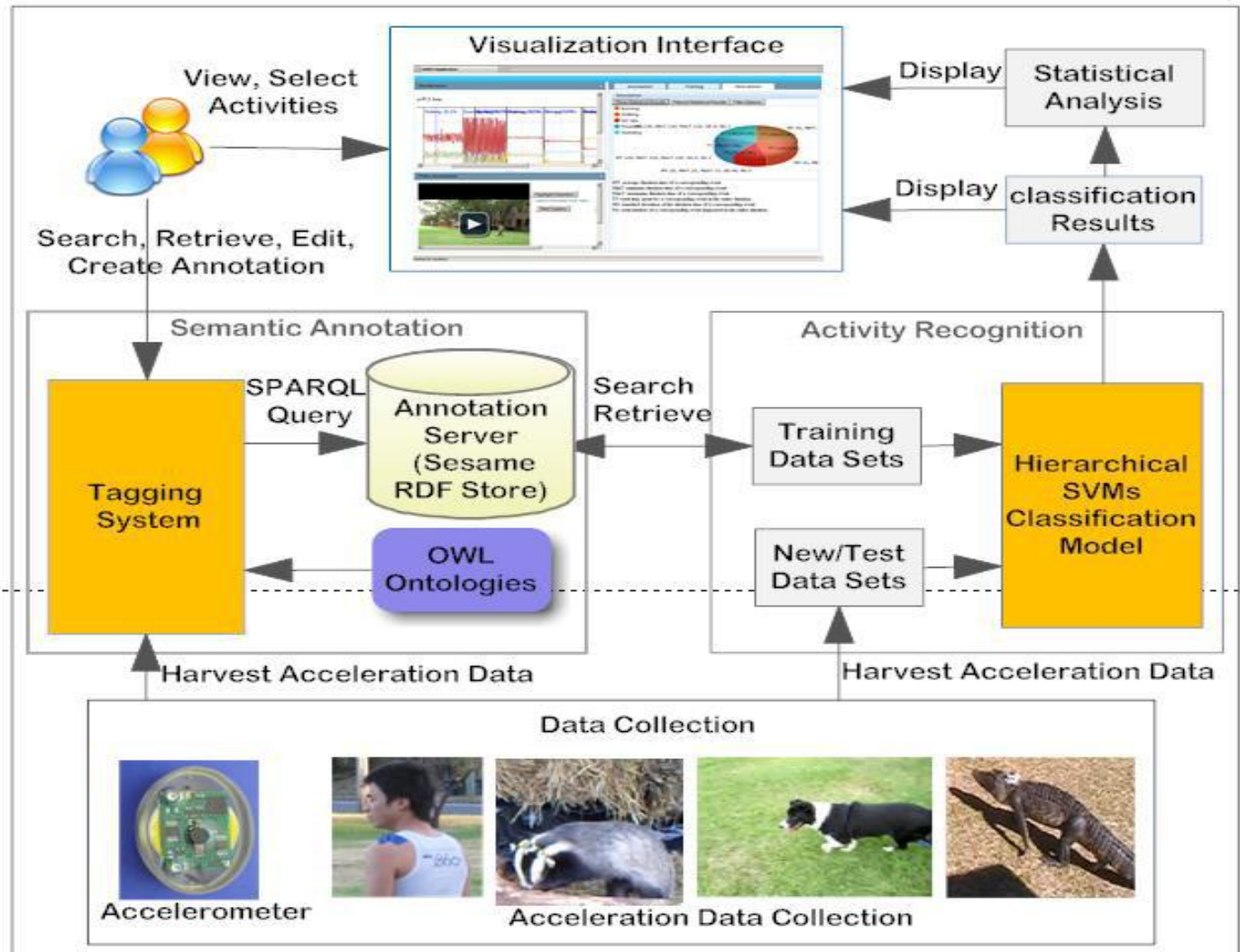
Capture Annotation From Video:

Start Capture End Capture

expand

Screenshot of the SAAR interface with human activity identification results

System Architecture

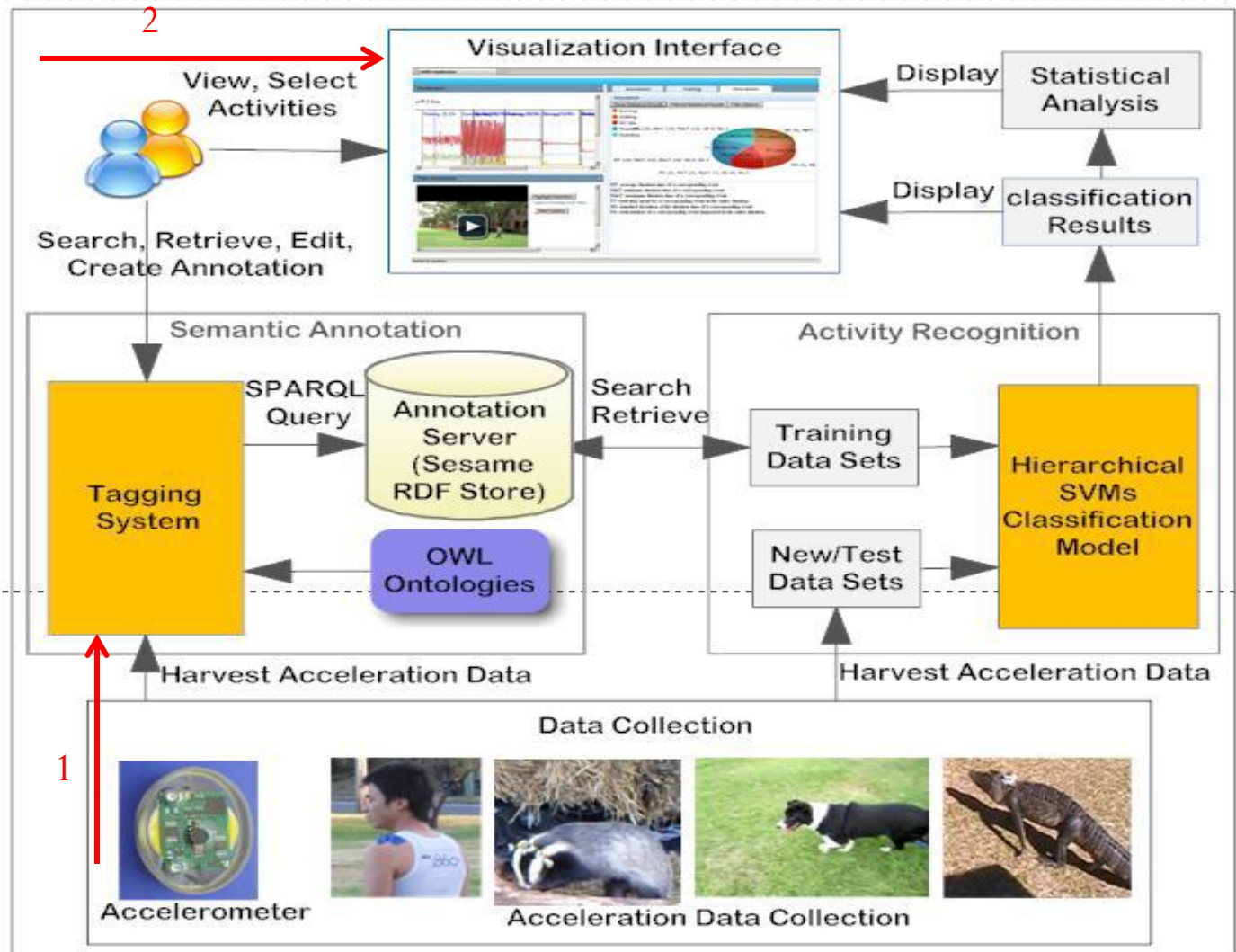


SAAR – Semantic Annotation and Activity Recognition System

Visualisation

Step 2:
display raw data
and video in the
visualization
interface

Step 1:
upload raw data
and videos

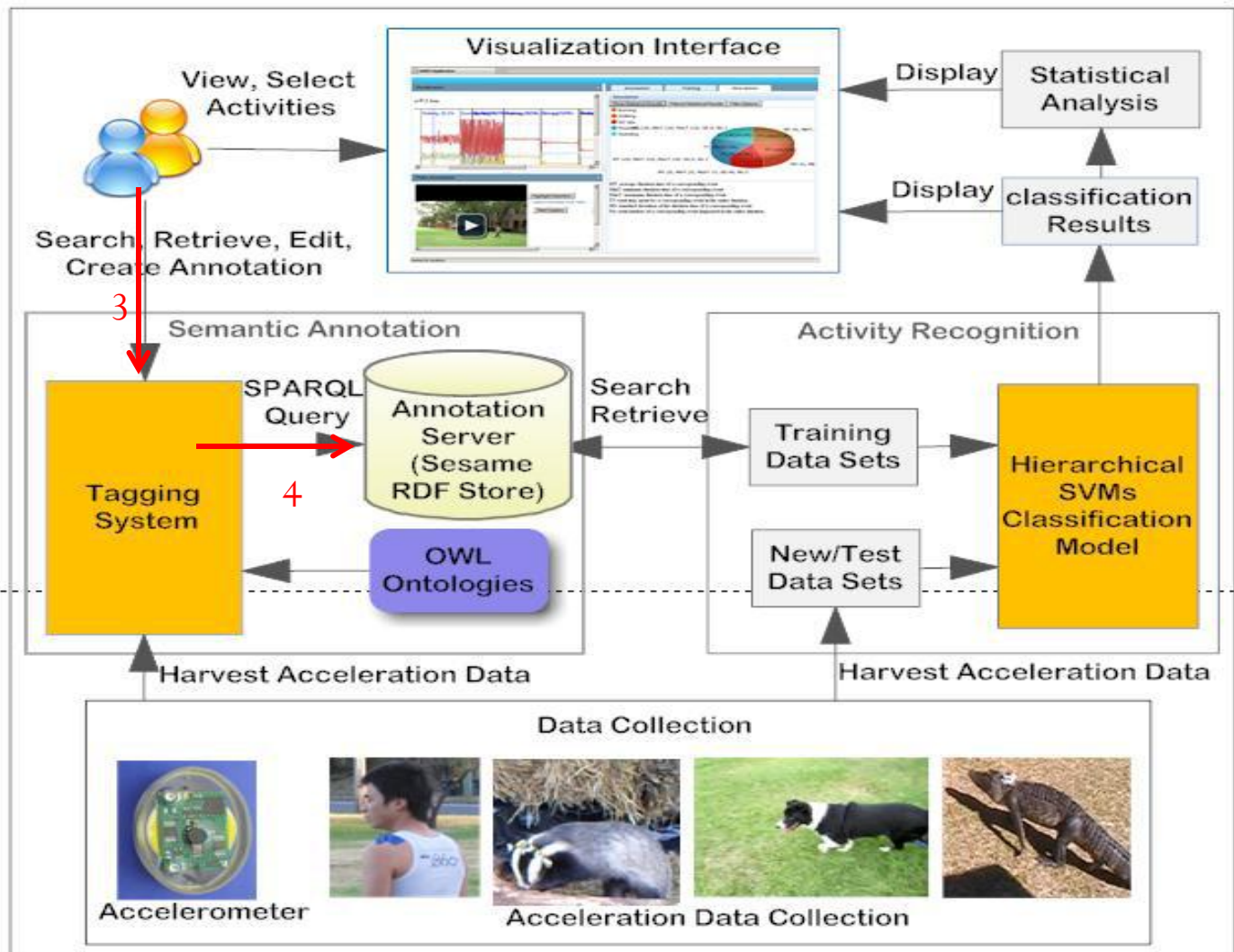


SAAR – Semantic Annotation and Activity Recognition System

Annotation

Step 3:
users create,
search, retrieve,
edit annotations

Step 4: created
annotations marked up
with ontologies,
and then saved in
the annotation server



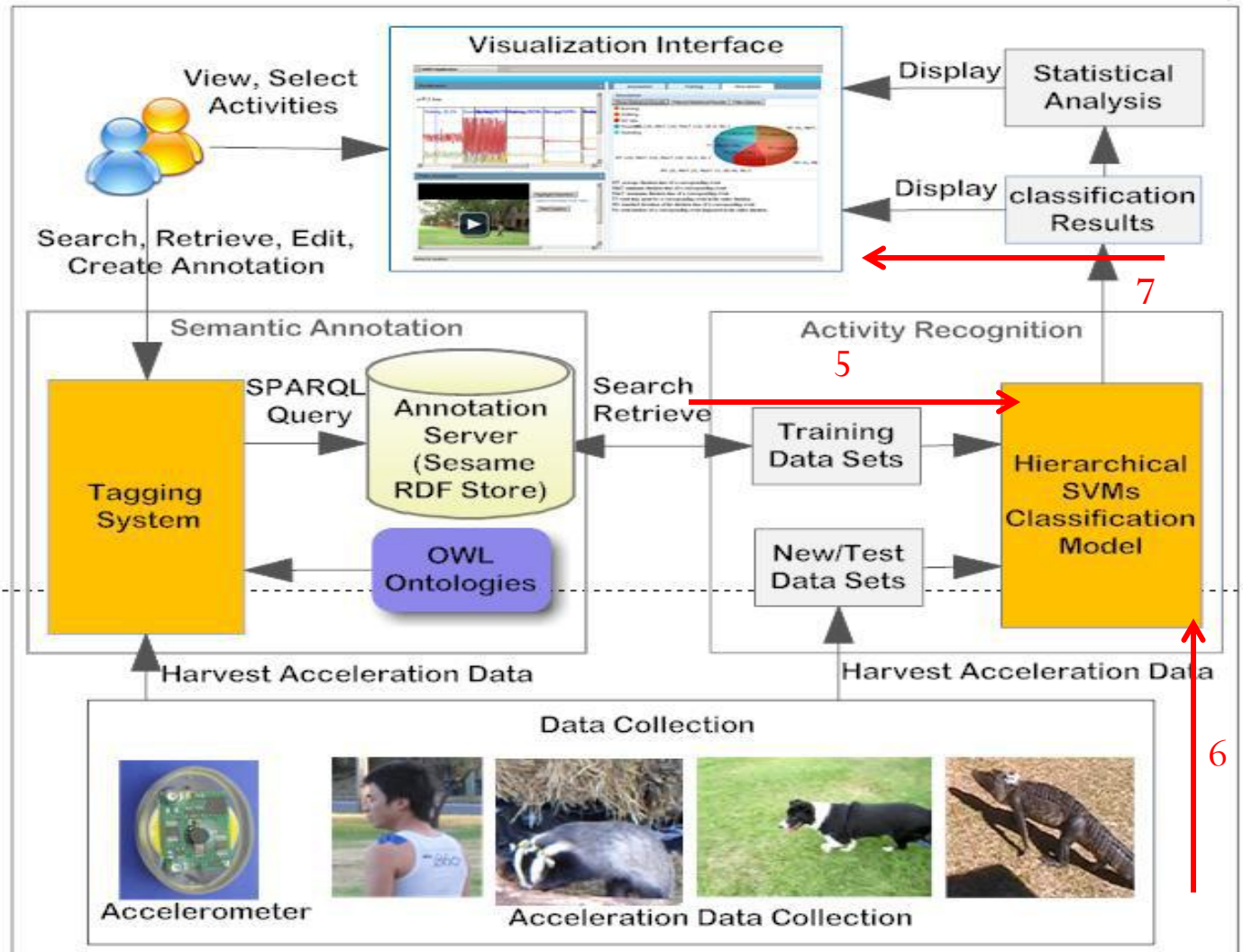
SAAR – Semantic Annotation and Activity Recognition System

Model training and use

Step 5:
search annotations
as training data
set to train SVMs
classification models

Step 6:
trained classifiers
take new acceleration
data as input to classify
animal activities

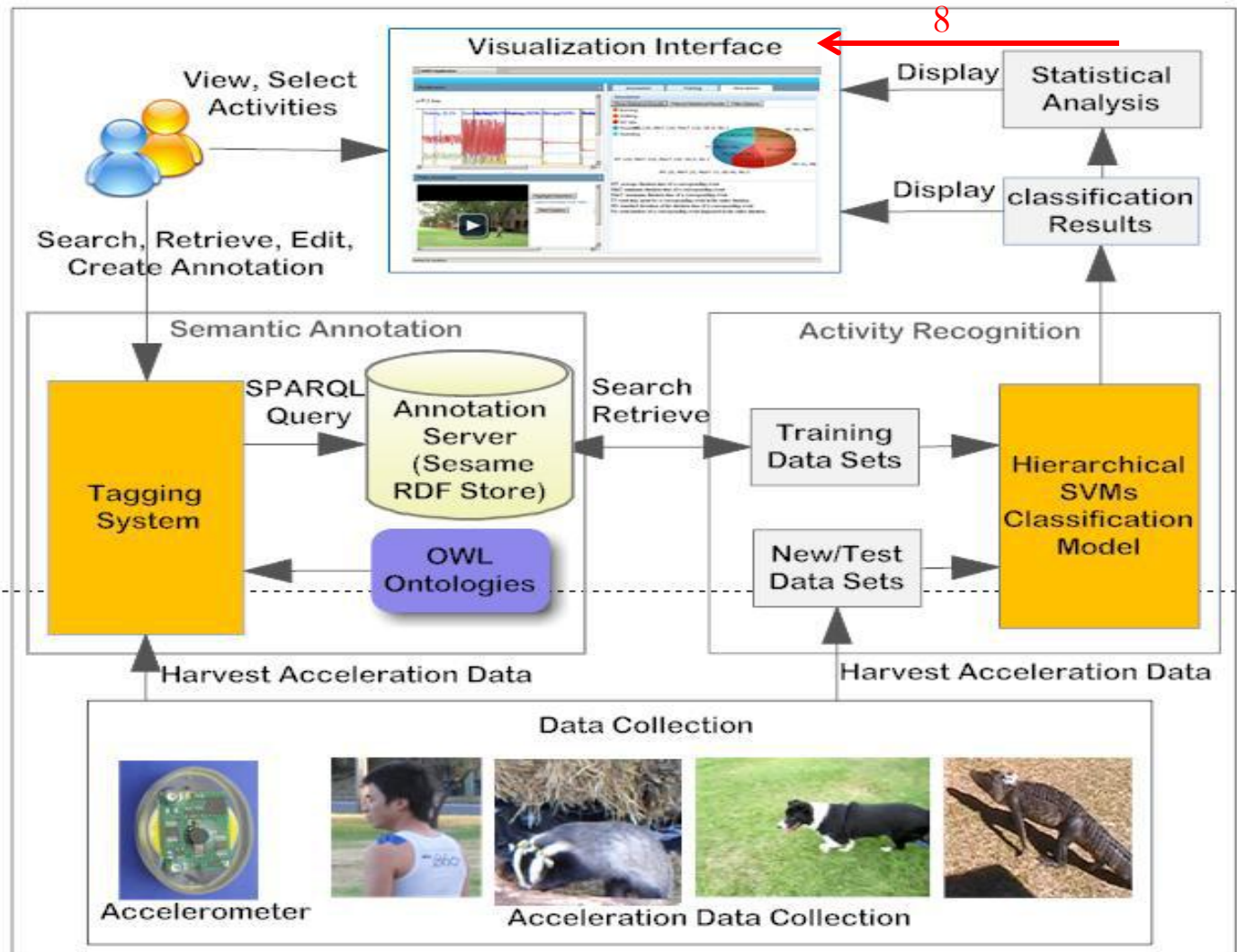
Step 7:
classification results
display in the
visualization interface



SAAR – Semantic Annotation and Activity Recognition System

Statistical summary

Step 8:
statistical analysis takes
classification results as
input and displays
the result in a pie chart



SAAR – Semantic Annotation and Activity Recognition System

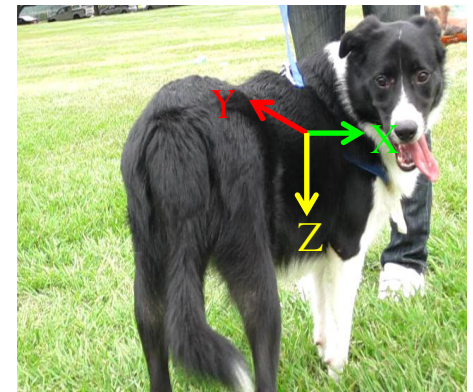
Data Collection-Human

- Human data collection
 - Location : University of Queensland
 - 4 males & 4 females
 - Age ranges from 25 to 38
 - For each voluntary
 - 3 minutes walking
 - 3 minutes running
 - 1 minutes sit-ups
 - 3 minutes standing
 - 3 minutes sitting
 - 3 minutes lying
 - Randomly perform these 6 activities over 15 minutes



Data Collection-Dog

- Dog data collection
 - Location: Brisbane
 - 6 dogs of different breeds
 - Height and weight
 - 20cm-55cm, 8.9kg-25.8kg
 - Each dog led by its owner to perform
 - 2 minutes walking, running, standing,
 - 2 minutes Sitting and lying
 - Randomly perform these 5 activities for 10 minutes
 - One well-trained king charles spaniel
 - 1 minutes foraging/digging
 - 1 minutes climbing



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

$$\text{Sensitivity} = \frac{\text{number of true positives}}{\text{number of true positives} + \text{number of false negatives}}$$

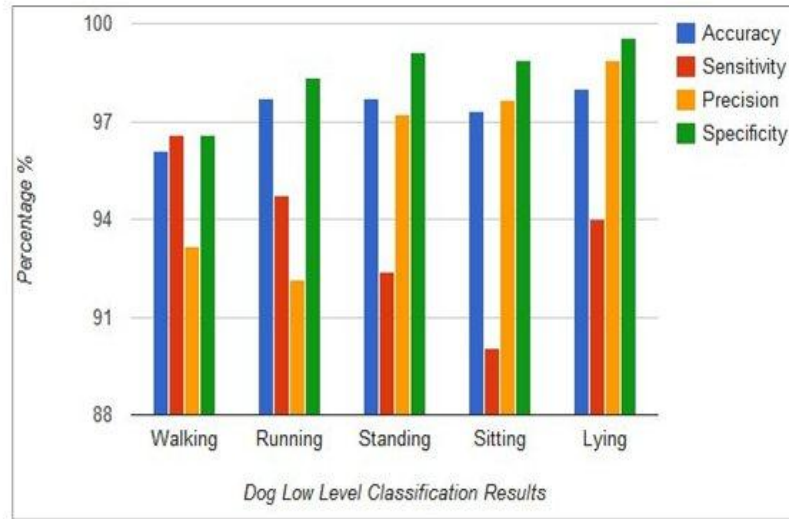
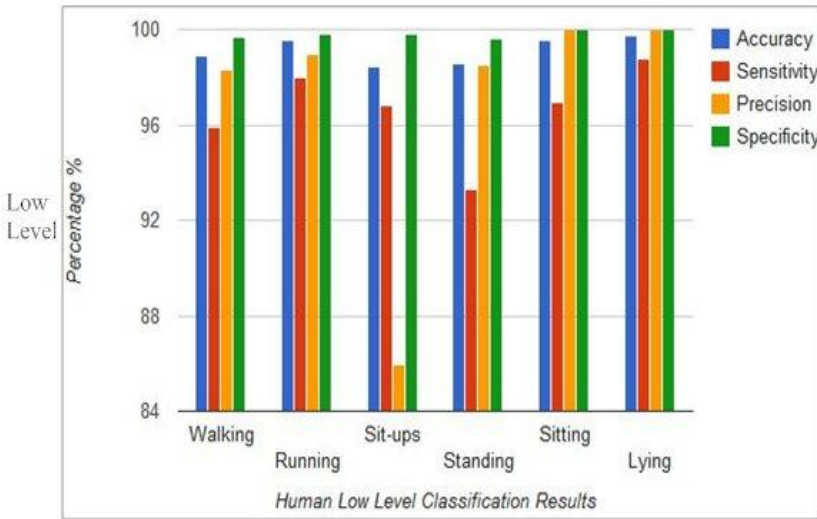
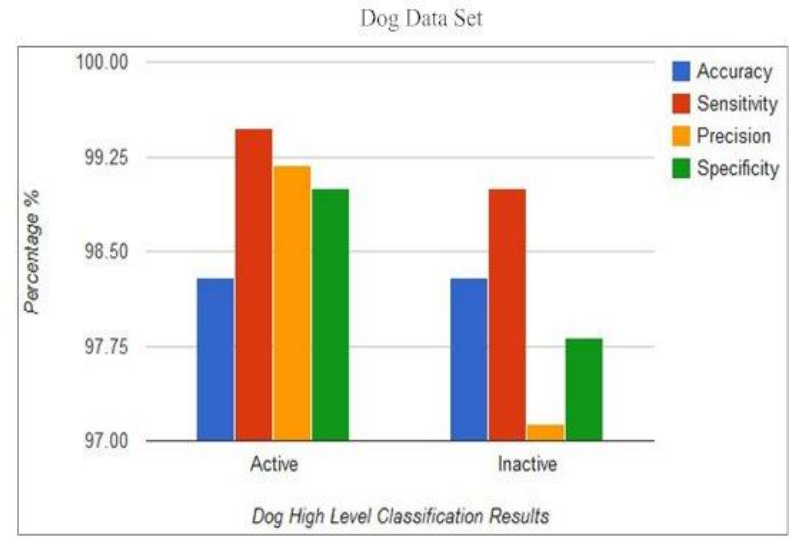
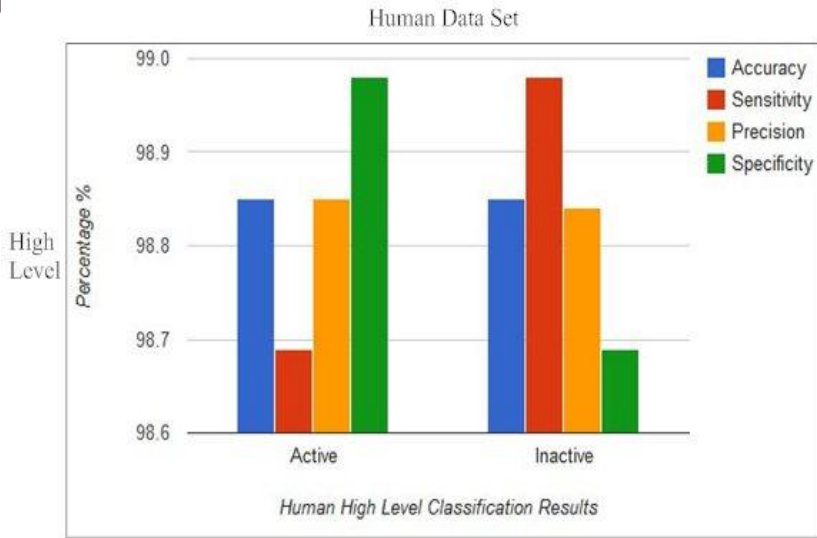
- Specificity

$$\text{Specificity} = \frac{\text{number of true negatives}}{\text{number of true negatives} + \text{number of false negatives}}$$

		Type as determined by a classifier	
		True	False
Test outcome	+ve	True positive	False positive
	-ve	False negative	True negative

Evaluation-Result-1

Humans and Dogs

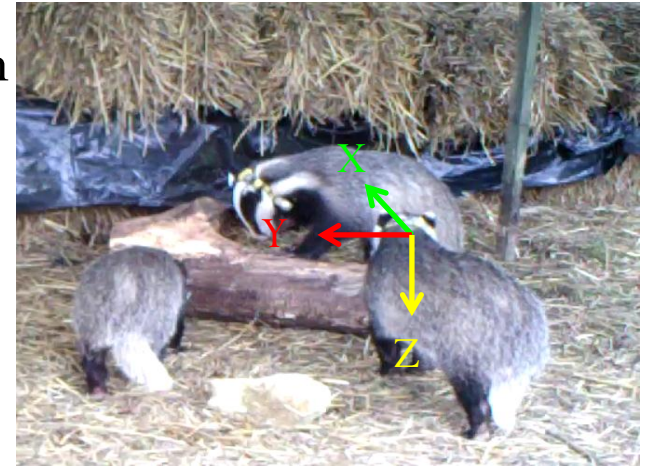


Humans

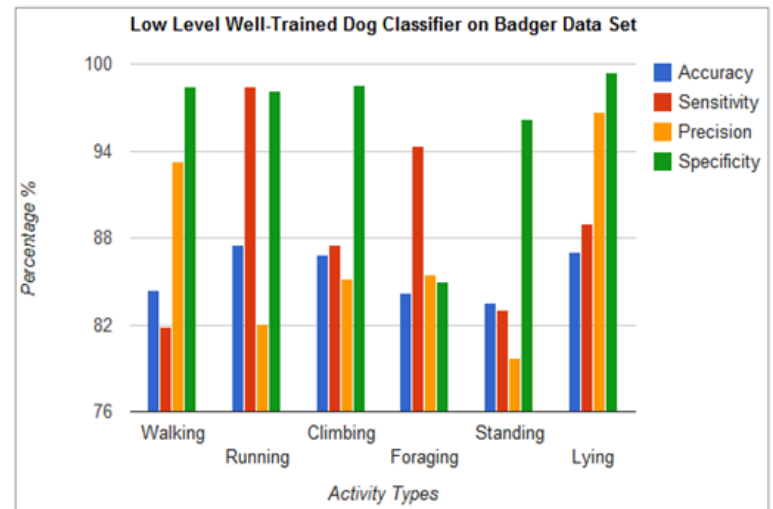
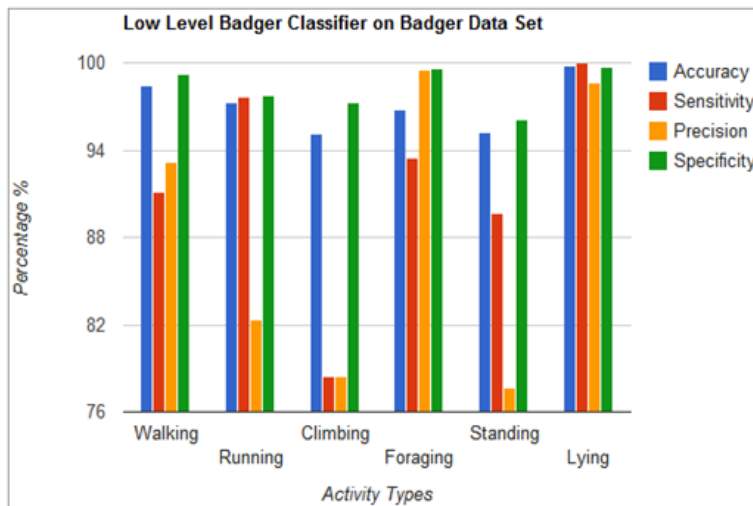
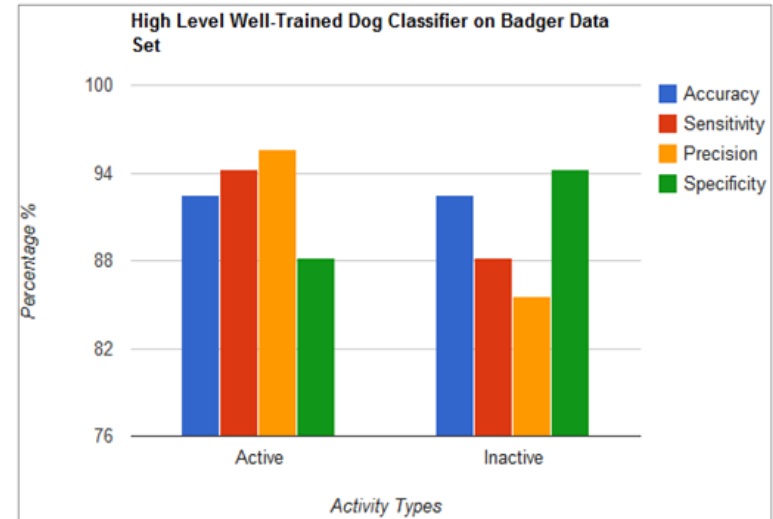
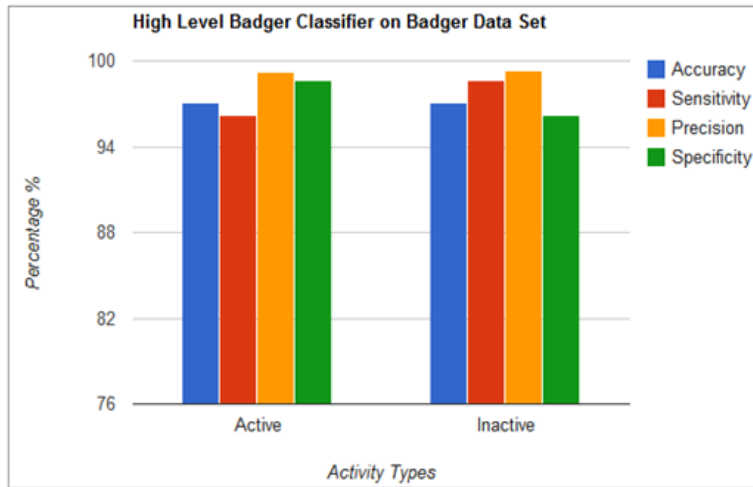
Dogs

Data Collection-Eurasian Badger

- Eurasian badger collection
 - Location: Somerset, United Kingdom
 - 3 Eurasian badgers
 - Six activities were recorded
 - Walking
 - Running
 - Climbing
 - Foraging
 - Standing
 - Lying



Evaluation-Result 2



Badger⁽³⁾

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

- Future work
 - Integrate GPS data to track animal trajectory + add map visualization
 - Acquire data from wild dingoes, captive tigers, wild birds
 - Apply captive models to wild animals
 - Dogs to foxes, dingoes
 - Birds to bats
 - Horses to camels
 - Evaluate different machine learning methods

Acknowledgement

- Owen R Bidder, from the Swansea Moving Animal Research Team (SMART) at Swansea University College of Science, for providing access to the badger accelerometer data, and for providing comprehensive and useful feed-back
- The China Scholarship Council



Questions?

- Thank you!
- Contact:
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 - Craig Franklin: c.franklin@uq.edu.au
 - Jane Hunter: jane@itee.uq.edu.au
- Websites
 - eResearch Group: <http://itee.uq.edu.au/~eresearch>
 - ECO-Lab: <http://www.uq.edu.au/eco-lab/>
 - SAAR: <http://seas.metadata.net/saar/>

