Animal monitoring based on IoT technologies

Luís Nóbrega, DETI/IT – Telecomunications Institute
André Tavares, DETI/IT – Universidade de Aveiro
André Cardoso, DETI/IT – Universidade de Aveiro
Pedro Gonçalves, ESTGA/IT – Universidade de Aveiro
Outline

1. Motivation
2. Overall Architecture
3. Animal Behaviour Monitoring
   - ML use case – detecting sheep’s posture
4. Conclusion and future work
Outline

1. Motivation
2. Overall Architecture
3. Animal Behaviour Monitoring
   - ML use case – detecting sheep’s posture
4. Conclusion and future work
Motivation

- Continuous growth of weeds needs to be controlled
- Traditional methods include:
  - Mechanical machinery
  - Chemical herbicides

- However, they are:
  - Onerous
  - Environmentally aggressive
  - Hard-working
  - Needs to be repeated through all the year
Motivation

So, how to remove vegetable species growing in vineyards and other farmlands without using expensive and aggressive mechanical or/and chemical methods?
Motivation

So, how to remove vegetable species growing in vineyards and other farmlands without using expensive and aggressive mechanical or/and chemical methods?

Using animals, specially ovines!!
Motivation

• An ancient method
• Advantages:
  • Reduction of environmental impact
  • Provision of land fertilization
  • Enhancement of the production
• Disadvantages
  • Cannot be used all the year to protect cultures
  • Need a automatized mechanism of animal handling

Solution?

SheepIT
(www.av.it.pt/sheepit)
Outline

1. Motivation
2. Overall Architecture
3. Animal Behaviour Monitoring
   - ML use case – detecting sheep’s posture
4. Conclusion and future work
SheepIT IoT Overall Architecture

IoT local network

Cloud platform
SheepIT IoT local network

- Collars are carried by sheep and sense animal’s behaviour
- Integrated sensors:
  - Accelerometer
  - Magnetometer
  - Ultrasounds transceiver
- Integrated actuators
  - Buzzer
  - Electrostatic stimulation circuit
- Use sporadic communications to enter in the network
- Send periodic sensed data to beacons
SheepIT IoT local network

- Beacons are installed in the intended grazing areas
- Send periodic data to collars to:
  - Collar’s synchronization
  - Virtual Fence implementation
  - RSSI-based localization
- Exchange periodic data with remaining beacons
  - Relay of collar’s data
  - Relay of protocol data
SheepIT IoT local network

- Gateway is an aggregation element
- Powerful version of a beacon. Integrates:
  - A standard beacon +
  - WPAN connection +
  - Greater processing power
- Additional functions:
  - Message transportation
  - Network Manager
  - Alarm generator
- Enables the integration between non-IP network and IP-based network
SheepIT IoT cloud platform

- Message Oriented Middleware (RabbitMQ)
- Receives JSON messages from the Gateway
- Supports AMQP and MQTT
- Based on Asynchronous publish/subscribe
- Implements a FIFO queue
- Implements security SSL/TLS
SheepIT IoT cloud platform

- Subscriber of the RabbitMQ
- Orchestrates all the operation inside the platform
  - JSON data translation
  - Alarms generation
  - Data processing (including ML)
  - Data persistence
- Stream process »» real-time analysis
- Batch process »» non-period analysis
SheepIT IoT cloud platform

- Storage of the data from:
  - Stream process
  - Batch process
- PostgreSQL
SheepIT IoT cloud platform

- Storage of the data from:
  - Stream process
  - Batch process
- PostgreSQL
- API framework to allow WEB development
- Interaction with upper layer applications
Outline

1. Motivation
2. Overall Architecture
3. Animal Behaviour Monitoring
   - ML use case – detecting sheep’s posture
4. Conclusion and future work
Animal behaviour monitoring

- Collars gather several data from sensors. They allow to monitor sheep’s...
  - .. posture
  - .. location
  - .. Infractions
  - .. Hours of activity
  - .. Travel times
  - .. Preferred pasture areas
  - .. Timings
  - .. Anomalous situations (panic, illness)
  - ....

- However, retrieve these information is not straightforward
- DM and ML techniques have a great potential to help solving these issues
ML use case – detecting sheep’s posture infractions

- Supervised learning algorithms to evaluate sheep’s posture
- Attributes:
  - 3-axis accelerometer »» neck’s tilt
  - Ultrasounds transceiver »» distance to the ground
- 3 hours of monitoring activity
- Timestamped Data recorded in a file for posterior classification
- Timestamped Video recorded
ML use case – detecting sheep’s posture infractions

- Dataset
  - 20555 entries
  - 75% for training
  - 25% for testing
- Manual classification:
  - Resting >> NOT INFRACTION
  - Eating from the ground >> NOT INFRACTION
  - Standing reaching for food >> INFRACTION
  - Walking >> NOT INFRACTION
  - Running >> NOT INFRACTION
ML use case – detecting sheep’s posture infractions

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Metric</th>
<th>ACC</th>
<th>TPR</th>
<th>TNR</th>
<th>PPV</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Forest</td>
<td>ACC</td>
<td>0.9696</td>
<td>0.8267</td>
<td>0.9861</td>
<td>0.8728</td>
<td>0.987</td>
</tr>
<tr>
<td>DT (C50)</td>
<td>TPR</td>
<td>0.9693</td>
<td>0.8475</td>
<td>0.9833</td>
<td>0.8539</td>
<td>0.986</td>
</tr>
<tr>
<td>XGBoost</td>
<td>TNR</td>
<td>0.9685</td>
<td>0.82674</td>
<td>0.9848</td>
<td>0.8625</td>
<td>0.988</td>
</tr>
<tr>
<td>KNN</td>
<td>PPV</td>
<td>0.9622</td>
<td>0.7702</td>
<td>0.9844</td>
<td>0.85.03</td>
<td>0.977</td>
</tr>
<tr>
<td>SVM</td>
<td>AUC</td>
<td>0.9642</td>
<td>0.7590</td>
<td>0.9879</td>
<td>0.8778</td>
<td>0.972</td>
</tr>
<tr>
<td>DT (rpart)</td>
<td></td>
<td>0.9591</td>
<td>0.8211</td>
<td>0.9750</td>
<td>0.8728</td>
<td>0.970</td>
</tr>
<tr>
<td>Naïve Bayes</td>
<td></td>
<td>0.9527</td>
<td>0.8795</td>
<td>0.9612</td>
<td>0.7230</td>
<td>0.979</td>
</tr>
</tbody>
</table>

![ROC Curve](image)

IoT Vertical and Topical Summit for Agriculture

Luís Nóbrega, lnobrega@ua.pt

08-09 May 2018, Tuscany - Italy
ML use case – detecting sheep’s posture infractions

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Metric</th>
<th>ACC</th>
<th>TPR</th>
<th>TNR</th>
<th>PPV</th>
<th>AUC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Random Forest</td>
<td></td>
<td>0.9696</td>
<td>0.8267</td>
<td>0.9861</td>
<td>0.8728</td>
<td>0.987</td>
</tr>
<tr>
<td>DT (C50)</td>
<td></td>
<td>0.9693</td>
<td>0.8475</td>
<td>0.9833</td>
<td>0.8539</td>
<td>0.986</td>
</tr>
<tr>
<td>XGBoost</td>
<td></td>
<td>0.9685</td>
<td>0.82674</td>
<td>0.9848</td>
<td>0.8625</td>
<td>0.988</td>
</tr>
<tr>
<td>KNN</td>
<td></td>
<td>0.9622</td>
<td>0.7702</td>
<td>0.9844</td>
<td>0.8503</td>
<td>0.977</td>
</tr>
<tr>
<td>SVM</td>
<td></td>
<td>0.9642</td>
<td>0.7590</td>
<td>0.9879</td>
<td>0.8778</td>
<td>0.972</td>
</tr>
<tr>
<td>DT (rpart)</td>
<td></td>
<td>0.9591</td>
<td>0.8211</td>
<td>0.9750</td>
<td>0.8728</td>
<td>0.970</td>
</tr>
<tr>
<td>Naïve Bayes</td>
<td></td>
<td>0.9527</td>
<td>0.8795</td>
<td>0.9612</td>
<td>0.7230</td>
<td>0.979</td>
</tr>
</tbody>
</table>

![Graph showing ROC curves for different algorithms](attachment:image.png)
ML use case – detecting sheep’s posture infractions
Webplatform

Developed by Instituto de Telecomunicações, Aveiro

IoT Vertical and Topical Summit for Agriculture

08-09 May 2018, Tuscany - Italy
Webplatform

Ver Coleira no Mapa

Mapa

Developed by Instituto de Telecomunicações, Aveiro

IoT Vertical and Topical Summit for Agriculture
Conclusion

• Weed control entails on a significant economic and labor efforts from winemakers;
• Sheep may be an alternative if sheep’s posture could be conditionate
• SheepIT project aims at solving that issue
• Offers an integrated platform, since the IoT local network until a could computational platform
Conclusion

• The overall architecture was implemented and a ML use case was tested
• Data was gathered using the implemented network and ML algorithms used to detect posture infractions
• DT were specially relevant to retrieve useful information to the algorithm development
Future work

• Extend the posture control algorithm for lands with big slope (as can be found in Douro’s region)
• Evaluate the platform performance and scalability with larger amounts of devices
• Evaluate other ML use cases (e.g. detection of illness, panic attacks, patterns of movement, food preferences, etc).
Thank you for your attention!

Questions?
EXTRA SLIDES
SheepIT IoT Networking Architecture

- Sporadic requests
- Periodic sensor data
- Periodic protocol data

Collars

Beacons

Gateway

- Periodic sensor/protocol data
- Periodic Inter-beacon sensor/protocol data
SheepIT IoT Networking Architecture

- uC common structure
  - Beacon window, where beacons send short synchronization and protocol data;
  - Turn-around window for local processing
  - A window for transmitting specific data to each uC
    - Eg. In a uC type 2, the window is used for collar’s data transmission