Study of animal movement: using the TinyML kits for monitoring

Laila Daniela Kazimierski
Interdisciplinary animal movement research group
Centro Atómico Bariloche - Río Negro - Argentina
The beginnings
Tortoise *Chelonoidis chilensis*

Main threats for the species:
- Habitat fragmentation.
- Livestock.
- Illegal trade as a pet.

Estimated distribution of *Chelonoidis chilensis*
General objectives

Answer basic questions about the biology of animal species. How?

- Monitoring and characterizing animal behavior.
- Developing movement models.

Objectives with TinyML kits

Optimize the animal monitoring. How?

- Automatically detecting, without direct observation, the activity carried out by animals.
- Automating the device operation based on the activity of the animals.
Our own design

- Custom hardware to improve energy efficiency and size.

- Flexible firmware to adapt to other species and hardware.

- 150 MHz communication.

- TinyML compatible.

Data collection

- Eight individuals.
- Spring 2020 and summer 2021.
- GPS, accelerometer data and visual observation of activities.
Data analysis

- Label signal segments using observed behaviors.
- Train a ML algorithm that recognizes between different activities.
- Classify behavior of the animal in real time.

Example of accelerometer signal of a female digging a nest to lay eggs:
Machine Learning: movement or stillness

- Pre-Processing Data
- Design a Model
- Train a Model

**Tests Flow**

<table>
<thead>
<tr>
<th>Datos crudos</th>
<th>Características espectrales</th>
<th>Espectrograma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Versión</td>
<td>int 8 float 32</td>
<td>int 8 float 32</td>
</tr>
<tr>
<td>Aciertos movimiento</td>
<td>12.8% 12.6%</td>
<td>51.2% 97.2%</td>
</tr>
<tr>
<td>Aciertos quietud</td>
<td>0.5% 99.9%</td>
<td>0.1% 99.7%</td>
</tr>
<tr>
<td>Precisión</td>
<td>2.33% 85.56%</td>
<td>8.04% 99.27%</td>
</tr>
<tr>
<td>Pérdida</td>
<td>2.5 0.66</td>
<td>1.6 0.23</td>
</tr>
<tr>
<td>Tiempo de inferencia</td>
<td>2 ms 8 ms</td>
<td>1 ms 1 ms</td>
</tr>
<tr>
<td>Uso de memoria</td>
<td>2.1 kB 3.3 kB</td>
<td>1.7 kB 1.8 kB</td>
</tr>
<tr>
<td>Uso de RAM</td>
<td>26.5 kB 51.5 kB</td>
<td>19.2 kB 21.5 kB</td>
</tr>
</tbody>
</table>

**Accuracy**: 99.83%

<table>
<thead>
<tr>
<th></th>
<th>MOVIMIENTO</th>
<th>QUIETO</th>
<th>UNCERTAIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOVIMIENTO</td>
<td>99.3%</td>
<td>0.6%</td>
<td>0.1%</td>
</tr>
<tr>
<td>QUIETO</td>
<td>0.1%</td>
<td>99.9%</td>
<td>0.0%</td>
</tr>
<tr>
<td>F1 SCORE</td>
<td>0.99</td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>
Machine Learning: movement or stillness

Create library
Turn your impulse into optimized source code that you can run on any device.

- C++ library
- Arduino library
- Cube.MX CMSIS-PACK
- WebAssembly
- TensorRT library
- Ethos-U library
- Simplicity Studio Component
Using the TinyML kits as monitoring system
Using the TinyML kits as monitoring system

Step by step of the data logger prototype with Arduino Nano 33 BLE Sense:
https://github.com/droyktton/dataLoggerNano33BLE

Here is the arduino code to store the data:

And here is the python code that processes them:
https://colab.research.google.com/drive/1_9go_lZilCCMfnH9YfPFYoGr_VzLNvT9
Winners of the Innovative and Creative Project Award within the framework of the IoT Into the Wild Contest for Sustainable Planet 2022 with Seeed Studio

Conclusions and future ideas

- We can classify movement and rest in tortoises. We want to expand the classification labels: digging nests, copulation, etc.
- Notify the users' cell phone of the activities of the animals. Use this classification to automate devices.
- Incorporate GPS and batteries to more kits to use them in the next campaign.
- Implement the kit's microphone to identify specific behaviors such as copulation and be able to contrast it with the accelerometer signals.
- Generalize the results to use the device in other species.
- Migrate the trained neural network to our own design.
- Incorporate the use of LoRa.
- More courses of TinyML in our institute.
- Collaborate.
Thank you!

Laila Daniela Kazimierski

(All this happens within the framework of an interdisciplinary group)

Contact: laila.kazimierski@cab.cnea.gov.ar