Computer Vision Analysis of Octopus Fighting Behaviour

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Introduction

Through observation of two California two-spot octopuses (*Octopus Bimaculoides*) it was found that if allowed to approach each other, they will often fight to determine dominance and social hierarchy.

This fighting behaviour consists mostly of the two octopuses aligning and pushing each other around their environment, similar to two aquatic sumo wrestlers.

Figure 1. Octopus in Fighting Bout

The goal of this project was to use computer vision techniques to retrieve information about this fighting behaviour from recorded octopus footage.

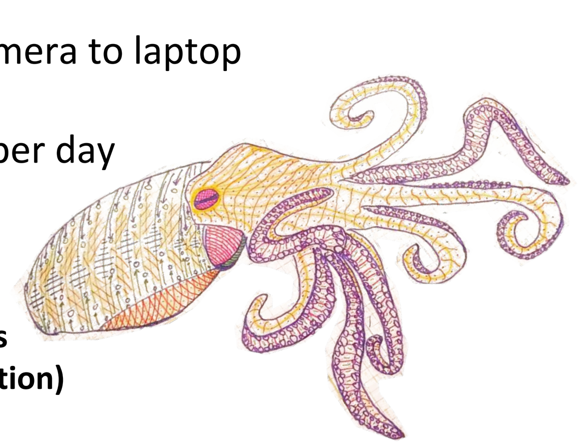
Project Setup

- Octopus chamber (Acrylic box + Go Pro holder)
- Go Pro camera
- Mini-USB cable
- Laptop
- Aquarium with sea water
- Two (2) California two-spot octopuses
- Empty, cleaned out milk jug
- Lamp, preferably with diffusive filter
- Paper towels (lots)
- Plastic cup

Figure 2. Chamber with Go Pro

Procedure:

1. Fill jug halfway with sea water
2. Shake jug to aerate it
3. Fill octopus chamber halfway with sea water
4. Set up lamp for even chamber lighting
5. Scoop up octopus from tank with plastic cup
6. Place octopus in chamber
7. Scoop up second octopus from tank
8. Set up Go Pro on top of the filming chamber
9. Place second octopus in chamber
10. Press record
11. Record for 15-30mins
12. Stop recording
13. Remove one octopus and place back in tank
14. Remove second octopus and place back in tank
15. Pour out remaining water from chamber and store away
16. Upload video from camera to laptop
17. Code
18. Repeat up to 3 times per day



Bimac Octopus (Artist's Rendition)

Methods

All the collected video was processed in a series of Jupyter notebooks, each extracting one feature of the data; the primary libraries used were: OpenCV-Python, NumPy, SciPy, matplotlib, imageio, and TensorFlow.

Collected vectors included:

- Average octopus brightness
- Average octopus speed
- Distance between octopuses
- Contour gradient of octopuses
- Time/Frequency of octopus contact
- Octopus breathing frequency
- Average octopus area
- Specific Interval Brightness

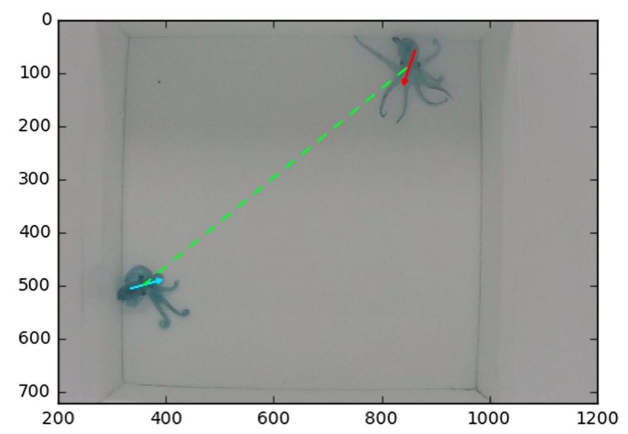
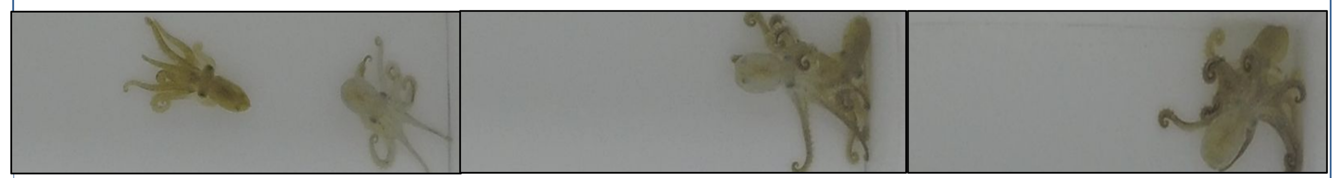


Figure 4. Angle/Distance Tracking of Octopus

Two Identified Behaviours: Pokes and Bouts

Two distinct behaviours were identified in the proceedings of these octopus fights. The first was prolonged contact with tentacle alignment where the two attempted to push each other around, hereby referred to as a *bout*.



The second was a behaviour exhibited when an overly aggressive octopus was put into the chamber with a more passive one, the aggressor would reach out a tentacle to grab at the passive octopus before rapidly backing off, these are hereby referred to as a *poke*.

Results: Tangential Approach and Rapid Angular Alignment

In both behaviours it was found that immediately following the initial point of contact between the octopuses (t = 0s), the angular difference rapidly decreased, meaning the octopuses would come to face one another. In the poke behaviour, however, the octopuses would then rapidly disengage and face away from each other. It is important to note the near constant angular difference leading up to contact, implying a tangential approach between the two octopuses as opposed to them entering the fight head on (fig. 5).

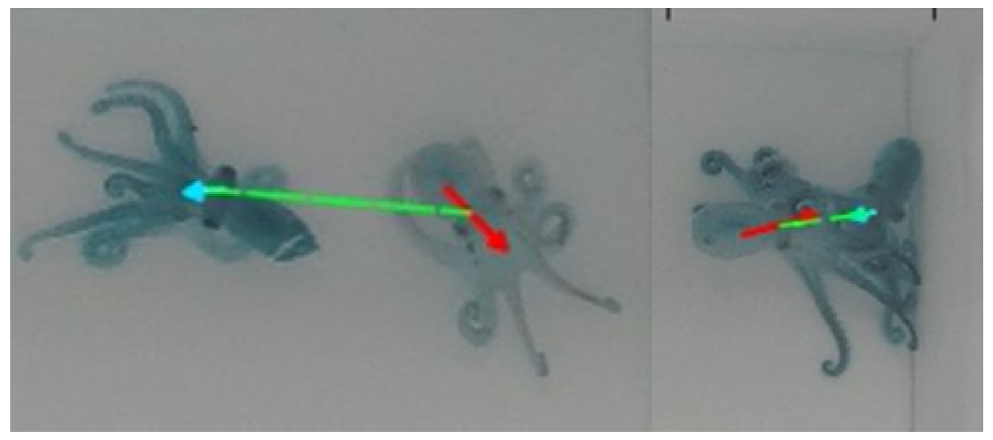
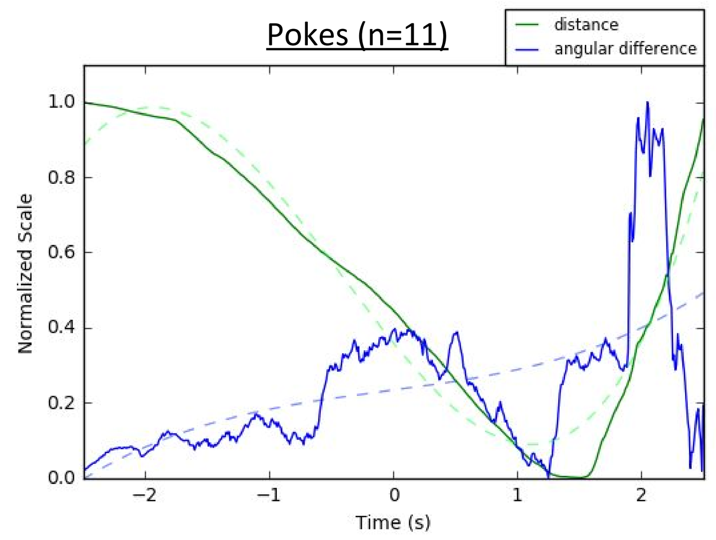
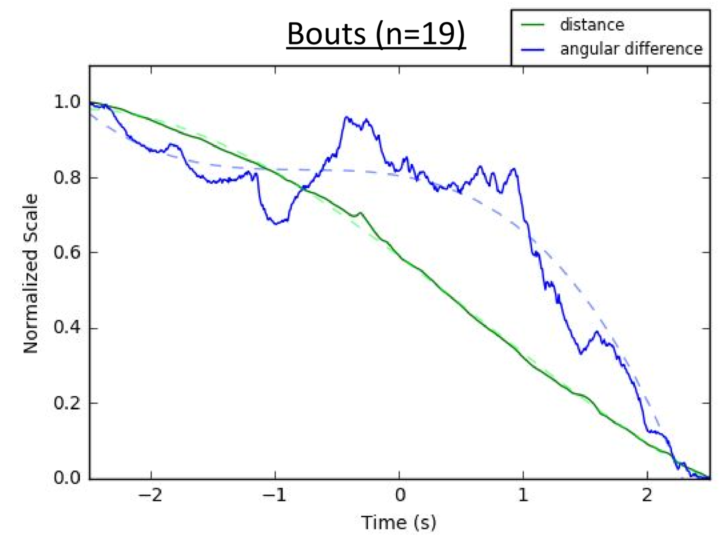


Figure 5. Octopus Angular Alignment

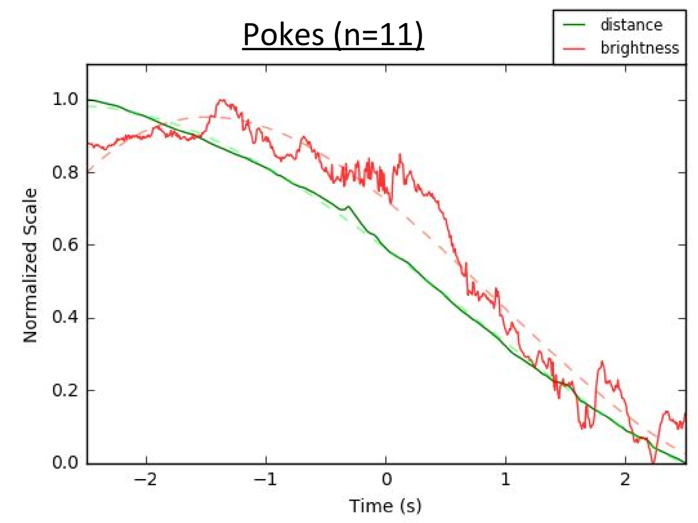


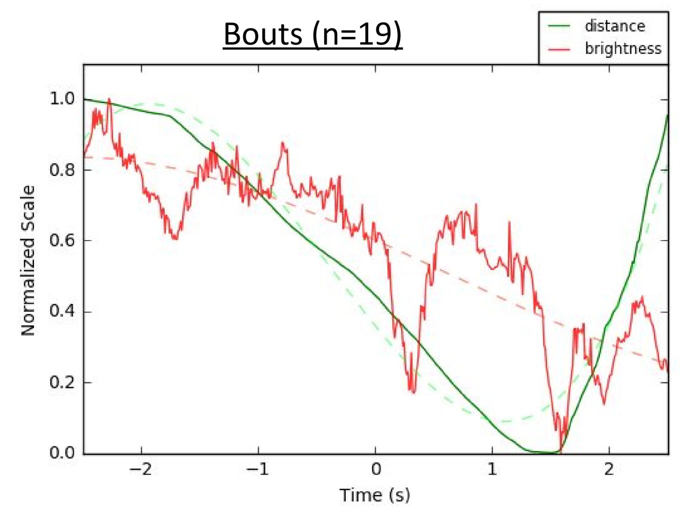


Results: Brightness as Attack Indicator

From the 19 trials in the bout category it was discovered that there was a **98.1%** correlation between the relative brightness of the octopuses and the distance between them (in the 4 second timeframe surrounding the point of contact. It was prominently only the attacking octopus who darkened their tone as they approached contact with their opponent (fig. 6). The poke behaviour, however, showed two sharp decreases in octopus brightness: one flash of colouration immediately following point of contact, and a second right as the poking octopus started to back away (indicated by the rapid increase in distance).

Figure 6. Sharp Decrease in Brightness of Attacker





Analysis: Poke or Bout, What's What?

Manually distinguishing pokes from bouts and timing when they happen is an arduous task that is better left to a computer program. By filtering the background from the octopus footage, creating two major contours of the octopuses, and tracking their respective areas it is possible to see when the two octopus are in direct contact (fig. 7), and when they are separate (fig. 8). When in contact, they become one contour, meaning the ratio of size between the first and second contour rapidly increases. By measuring this duration of single contour we can filter for pokes (t<500ms), and by taking its gradient we can find exact times of initial contact (fig. 9).

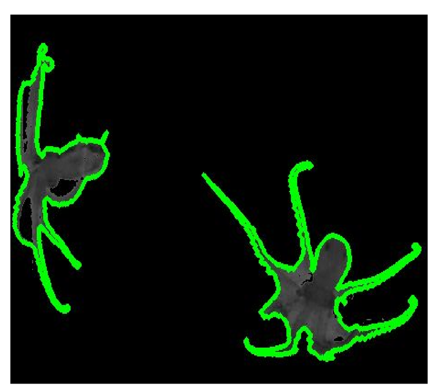


Figure 7. Octopus Separate

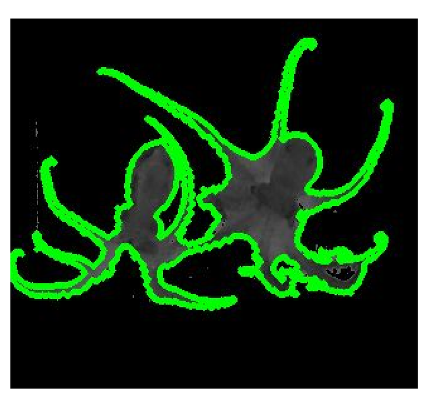


Figure 8. Octopus Together

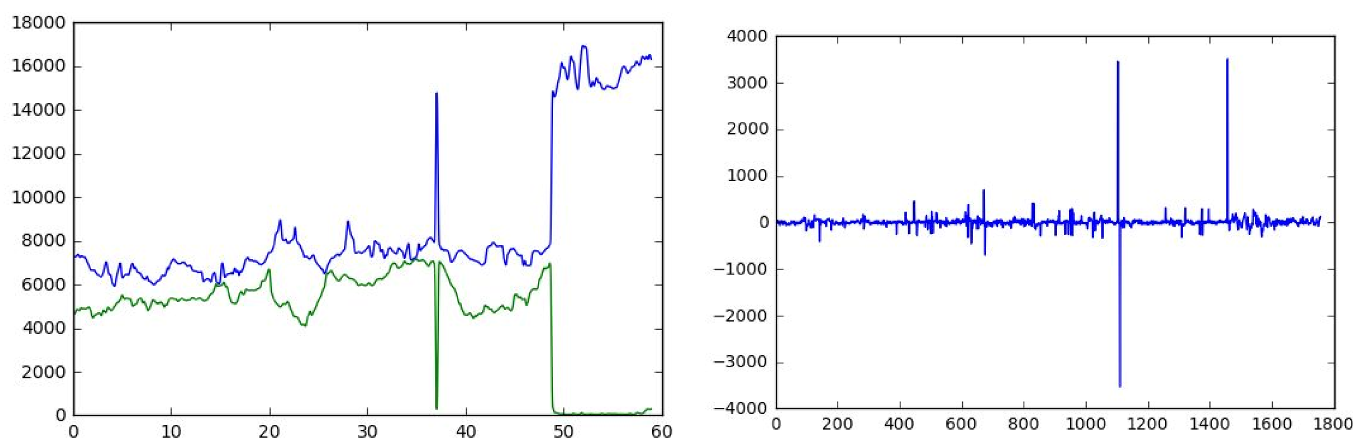


Figure 9. Contour Areas (left), Contour Gradient (right)

Analysis: Brightness as a Predictor

Using the knowledge that a drop in brightness is related to an approaching attack it is possible to train a system to predict when the point of contact will occur between two octopuses, given the graph of their brightness versus time.

Using logistic regression, with the training set of several already classified brightness vectors (fig. 10) the code predicts a point of contact typically within 30 frames, or slightly more than half a second (fig. 11).

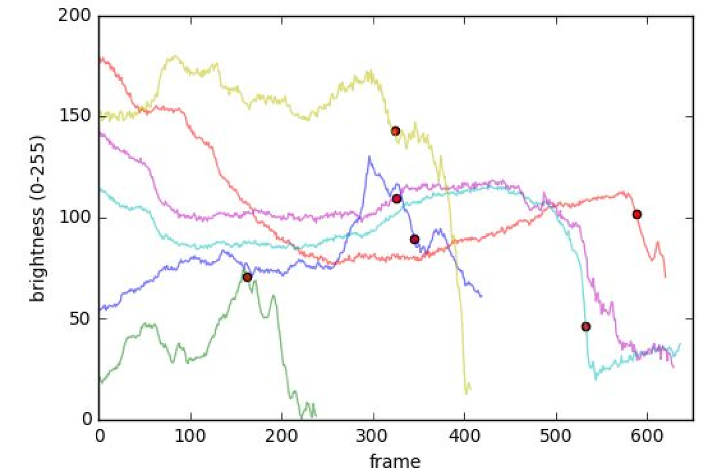


Figure 10. Octopus Brightness, Marked Contact

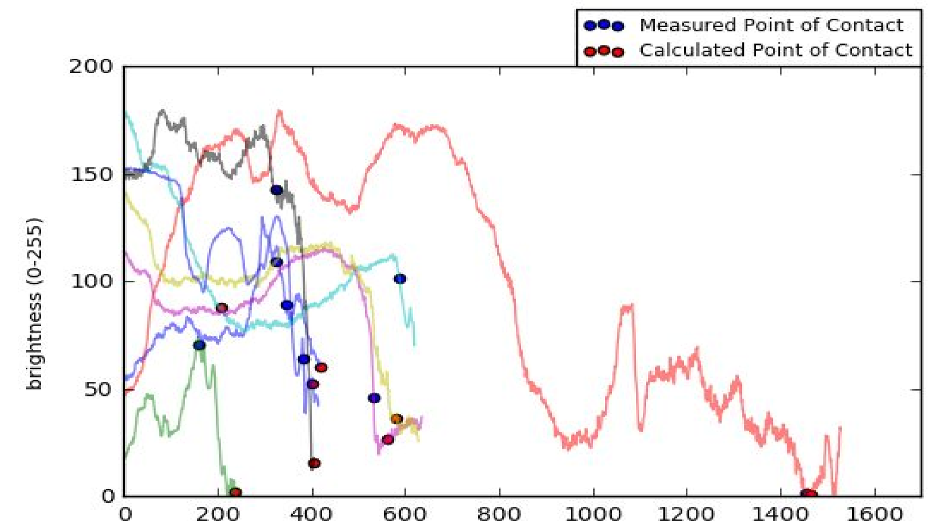


Figure 11. Predicted vs Measured Point of Contact

Discussion

The tangential approach displayed by octopuses approaching a bout is interesting as it appears very similar to the way much larger organisms such as silverback gorillas approach a confrontation, appearing to not make eye contact until the distance closes below a certain point and conflict becomes unavoidable.

This identification of conflict behaviour, in addition to the resilience and general ease of maintaining these animals, makes the use of Bimac octopuses as a behavioural assay very promising. Small genetic modifications may be applied to the animals in-vitro, and larger behavioural outcomes easily tracked and analysed with the aide of computer vision and machine learning techniques.

As no code written for this project is necessarily limited to use on only octopuses, the methods for this analysis could very possibly be applied to questions of behaviour in any number of test species.

Acknowledgements

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