Dynamics of Social Networks and Collective Motion in Sheep

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With Jenny Morton, Damien Fay, Stephen Hailes, Alan Wilson
Why animal social networks?


• Animal welfare and conditions (Siobhan Abeyesinghe’s talk)

• Foraging and hunting and wildlife preservation (see Croft & Krause papers)
CHDI Project

• To measuring cognitive, locomotor, social dynamics and behavioral functions in a transgenic sheep model of Huntington's Disease.

• 100s of control and HD sheep

• Based in Adelaide, Australia

• Two trips a year to collect data
Equipment

• Differential GPS (GPS units + base station), accurate to 10 CM (consistent across loggers and Gaussian in nature), at 1Hz

• Weight ~500g including battery and harness

• ~1% of mean sheep’s weight, they are not bothered! (Gait analysis paper under review)

• Sheep carried them for few days before the social experiments
Define association, my friend!

- Old problem
- Association !~ kinship
- Proximity !~ association
- Bluetooth & RF-ID range != association
- SO, how are two individuals related?
Defining spatial-temporal criterion and sampling rates

• 3 groups of sheep (N=10,18,18) from a founder flock of ~300 individuals, isolated for a number of weeks

• Then mixed these three groups together into a single cohort (n=46)

• Familiar individuals should be able to recognise another (Kendrick et al. 1996; Kendrick et al. 2001; Ligout and Porter 2004)

• We then track the network structure of the flock over the first four hours when mixed.
K-Means clustering

• Previous research on Merino sheep suggests individuals associate with a spacing of 1 - 3 meters (Lynch and Hinch 1992).

• We calculated adjacency matrices for 30 different spatial-temporal scales ranging from 1 minute at 1 meter to 5 minutes at 3.5 meters.

• Used k-means clustering algorithm

• K=3
K-means results

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<th>Time (minutes)</th>
<th>Distance (meters)</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
<th>2.5</th>
<th>3</th>
<th>3.5</th>
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<tr>
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<td>0.60</td>
<td>0.59</td>
<td>0.85</td>
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<td>0.81</td>
<td>0.80</td>
<td>0.75</td>
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</tr>
</tbody>
</table>

Warmer colours in the plot represent higher accuracy.
Spatial associations

(a) Group A

(b) Group B

(c) Group C

(d) Group A+B+C

Distance (meters)
Association network diagrams

(a) Group A

(b) Group B

(c) Group C

(d) Group A+B+C
Optimum sampling rate

• (a) Graph entropy rate over time, and (b) Frequency content of entropy

• phases: 1 = ‘holding pen’; 2 = ‘herding’; 3 = ‘entry into field’; 4 = ‘in field’
Entropy and connectivity

Measure of ease of spreading of information (e.g. a disease) in a network
Effect of sampling on the network

With sampling rate of 0.2 Hz (i.e. once every 5 seconds) approximately 90% of the signal is retained regardless of sheep activity

information of 70% and 80% are indicated with arrows for comparison
Questions?

http://www.phar.cam.ac.uk/ri/morton.html

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