Sensor networks for social interaction discovery at land and sea.

Measuring Social Structure in Animal Populations

Towards Telemetry on highly sparse “networks”

Lionel Sacks
ACSE Group
Dept of E&EE, UCL
www.ee.ucl.ac.uk/~lsacks/
Overview

- Current Work on Distributed Algorithms
- New Question – the Social Life of Seals
- Problem
- Initial Approach to Solution
Target Deployment

Measuring Impact on Coastal Erosion from Wind farms

Surface moored buoy, VHF comms (shore and/or other buoys), u/w comms and control of sensor packages, data storage.

Basic disposable sensor packages (e.g. temp, turbidity). Limited storage and power. u/w comms.

Enhanced disposable sensor package (e.g. temp, pressure, turbidity, current). Increased storage and power, u/w comms.
Distributed Algorithms in SECOAS

UCLs Focus:

- Adaptive Sampling
- Clustering
- Location/ID

- Clustering:
  - Ibisok Wokoma
- Location
  - Toks Adebutu
- Data Retrieval
  - Antonio Gonzaliz

- Model Dependent Data Sampling
  - Venus Shum
- Support Platform – kOS
  - Mat Brittan, Hammed Hadid
Key kOS Concepts:

Support platform for Distributed Algorithms

- Self Synchronising
  - Locally & globally
- Shared information model
  - Data Dispersed, not sent!
- Routing
  - Too much work
  - Not reliable
- Biologically inspired
  - Bits…
Real Biological Systems!

Flocking, pack, herd, etc. Animals: Have Structure

- Social Structure is a bit of a mystery…
  - E.g. seals in the natural works; but cows & badgers?
- Difficult to measure
  - Wide area, harsh environments, large MTBF
How important are “non-random models”?

Very

Case of Foot & Mouth

Culling Strategies
- IP infected premises and at-risk farms
- CD: Dangerous Contacts
- CP contiguous premises

the localized nature of 'IP-centred' ring vaccination means that neighbouring uninfected areas retain high levels of susceptibility, which can generate new epidemics by means of long-range 'sparks' of infection

Nature 421, 136 - 142 (09 January 2003); doi:10.1038/nature01343
“Modelling vaccination strategies against foot-and-mouth disease”
M. J. KEELING*, M. E. J. WOOLHOUSE†, R. M. MAY‡, G. DAVIES§ & B. T. GRENFELL
What do Seals do?

...Swim Away
Argos satellite tag tracks of 30 grey seal pups

Bernie McConnell, NERC Sea Mammal Research Unit, University of St Andrews
What is a node?

- A seal with a device which:
  - Can detect the ID of another seal at distance $d_e$
  - Record that ID, with time (locn?)
  - Communicate a history of encounters between nodes: Distance $d_c$
  - Communicate a history of encounters to ‘base’.
  - Probably Ultrasound and / or RF

Bernie McConnell, NERC Sea Mammal Research Unit, University of St Andrews
Can we distinguish social structures?

Just About, by measuring Encounters

The Triad Significance Profile (TSP)

Ref: Science Mag; Volume 303, Number 5663, Issue of 5 Mar 2004, p. 1538
Technical Problem Space

‘nodes’ may not move in predictable directions

- To Know that:
  - A ↔ B
  - E ↔ C
  - C ↔ B
  - A ↔ C

- Each ‘node’ both
  - Records encounter
  - Acts as
    - ‘router’ or
    - ‘db’ component
What is an Encounter?

Parallels and differences....

**Biological**
1. Out of range
2. Similar region of interest (food, nesting etc.)
3. A & B can detect each other
4. Encounter – social / epidemiological / etc.

**Technical**
1. Out of range
2. Minimum physical detection (intermittent, coherent signal)
3. Establish media access, exchange identity. An encounter is established and recorded
4. Can transfer data (encounter histories)
Telemetry?

Retrieving maximum information, despite high MTBF

- This cannot be a routed network:
  - No Direction vector
  - Infinitely small chance of, even transient, end to end.

- More like a Distributed Data Base
  - Loose integrity
  - Delete possible by base station

- Coherence provided by gossip…
  - Dispersion of information like an epidemic…
  - Over the Social Network → to be measured
The Big Issues
Challenges & Opportunities…

Exploit current Sensor Node developments, then:

- **Science:**
  - Do we have sufficient statistical power?
  - Using the social network to measure the social network (well, for the telemetry)
    - Surmountable Systematics?

- **Other Issues / Applications:**
  - *E.g.* DARPA – ATO – Survivable Networks
  - Standard “information dispersion”?
Its going to be a messy business... 
... but interesting!

Thank you for Listening.