A Reputation and Trust Based Multi-Modal Sensor Network for Environmental Monitoring

Edel O’Connor
Prof. Alan F. Smeaton & Prof. Noel E. O’Connor

This Beaufort Marine Research Award is carried out under the Sea Change Strategy and the Strategy for Science Technology and Innovation (2006-2013), with the support of the Marine Institute, funded under the Marine Research Sub-Programme of the National Development Plan 2007–2013.
Presentation Outline

- Issues with in-situ WSNs.
- Multi-modal sensor networks.
- Data aggregation.
- Pilot studies:
  - River Lee water depth study.
  - Water level prediction for adaptive sampling.
- Trust and reputation framework.
Water Management

• Water management is an important part of the monitoring of the natural environment.

• For many years water managers relied on field measurements for coastal monitoring and water quality evaluation.

• However this process is being revolutionised through the introduction of new technologies such as sensor networks.
Issues

- Current state of the art in chemo/bio-sensor networks not at a stage for reliable long-term large scale deployment.

- Even without the complexity of chemo-bio sensing, still considerable issues
  - Sensors subject to harsh conditions
  - Bio-fouling
  - Limited spatial resolution
  - Difficult to monitor large areas over long periods of time
  - Unsuitable for certain environments and the immediate detection of certain events
  - Developments in sensor research pushing towards ever cheaper systems
  - Huge information overload – user requires reliable event detection.
Multi-modal sensor networks

- The incorporation of alternative sensing modalities such as visual sensors, alongside an in-situ WSN can help to overcome some of these problems.
# Test Sites

<table>
<thead>
<tr>
<th>Requirements</th>
<th>River Lee</th>
<th>Galway Bay</th>
<th>River Tolka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Security</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Multiple sensing modalities</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interesting from marine perspective</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Data Aggregation – Camera data

Beaufort Research Awards in Marine Sensing
Data Aggregation – Satellite data
In-situ sensor data and context data

Deploy: River Lee

Rainfall Radar processing

SmartBay: Galway Bay

Image: Marine Institute

Beaufort Research Awards in Marine Sensing
Multi-modal sensor networks – adaptive sampling
Reputation and Trust-based multi-modal sensor network

- Development of a reputation and trust-based multi-modal sensor network
- Adaptation of a model developed for in-situ sensor networks known as RFSN (RFSN Ganeriwal & Srivistava 2008).
- Adaptation of this model to multi-modal sensor networks
Community of Sensor Nodes
Community of Sensor Nodes

RFSN

WATCHDOG

Series of outlier detection protocols, outputs cooperation metrics for each of the nodes.

REPUTATION

Updates reputation for each of the nodes [l, j, k, l] i.e. R_{ij}, R_{ik}, R_{il}, R_{im}

Cooperation metrics

trust

External evidence
Community of Sensor Nodes

RFSN
Community of Sensor Nodes

RFSN

[j,k,l,m]

WATCHDOG

Series of outlier detection protocols, outputs cooperation metrics for each of the nodes.

REPUTATION

Updates reputation for each of the nodes [l, j, k,l] i.e. $R_{ij}, R_{ik}, R_{il}, R_{im}$

Cooperation metrics

trust

External evidence
To sum up...........

- Multi-modal sensor networks provide:
  - Increased information and early warning information regarding environmental events.
  - More efficient and effective sensing.
  - More reliable event detection which leads to improved monitoring and scientific analysis.
  - A smarter adaptive sensor network that continuously monitors our environment, detects changes in the quality of our environment and reacts to those changes.
Acknowledgements

• Beaufort Research Awards in Marine Sensing
• Marine Institute
• Prof. Alan Smeaton, Prof. Noel O’Connor, Prof. Dermot Diamond.
• CLARITY – Centre for Sensor Web Technologies, Science Foundation Ireland under grant 07/CE/I1147
• SmartBay project
• Deploy project
• HRDDS (GHRSSST Project) and David Poulter at the National Oceanography Centre, Southampton, UK