Telecommunication as a Vehicle to Mitigate the Impact of Climate Change

Keynote

Dr David L Ndzi
School of Computing, Engineering and Physical Sciences
University of the West of Scotland
Outline

• UN’s Sustainable Development Goals

• Role of Telecommunication

• Climate Change

• Rain Prediction

• River Characteristics

• Remarks
SUSTAINABLE DEVELOPMENT GOALS

2. Zero Hunger

4. Quality Education

3. Good Health and Well-Being

6. Clean Water and Sanitation

9. Industry, Innovation and Infrastructure

13. Climate Action

11. Sustainable Cities and Communities
Terrestrial & Satellite Communication Research

Rain dynamics

Scattering from trees, Traffic and buildings

HAP

Urban environment

broadband wireless access
Heavy Rains & Flooding

- Increasing incidences of heavy rains and floods
- Unreliable prediction systems
Droughts

- Rising temperature, long dry seasons and drought
Too much water been released during rain season leads to flooding to downstream.

Too much water been released during drought season leads to water shortages in the reservoir.
Impact
Rain Prediction: NIMROD Radars

For Europe: Space resolution: 5 km
Time resolution: 15 mins

For UK: Space resolution: 1 km
Time resolution: 5 mins
Issues with Rain and Drought Predictions (Countries most affected)

• Unlike in temperate climate, rain tropics is
  – Often convective with high intensity
  – Small cell size
  – Dynamic with high spatial and temporal variations

• Limited data
  – Poor resolution satellite and/or radar data
  – Uncoordinated rainguage data

• Limitations of available models
• Climate change
Weather Stations

Temperature
Humidity
Atmospheric Pressure
Wind Speed
Wind Direction
Rainfall Rate

Replace with this?

Temperature
Humidity
Atmospheric Pressure
Wind Speed
Wind Direction
Rainfall Rate
Questions System will need to answer

- Is it raining?
- Is it going to rain?
- How long before it rains?
- How heavy will the rain be?
- Where else will it rain?
- How will it change the river?
- Will it cause flooding?

Single point prediction

Network prediction
Is it going to rain? 

- No
- Yes

When?

- Not soon
- Soon

How heavy?

- Light
- Heavy

Will it cause floods?

- No
- Yes

Disaster Alert

- Inform residents

Farmer
- Irrigate
- Don’t irrigate

Dam operator
- Release water for use only
- Release water from dam to prevent over-fill/flood
ENVIRONMENTAL SENSING

- For Weather Prediction
  - Real-time
  - Early warning system

- Cloud build up
  - Rainfall
    Rate, cell size, dynamics

- Flood
  Location, level, how long

- River/dam
  Level, flow rate, water quality

GSM/Network Warning

Flood prediction
Time lag between rainfall, river level and flow rate

Level (meter), flowrate (cubic meter /sec) of Sungai Pelarit Level station, Rainfall rate (mm/h) of Kaki Bukit and Lubuk Sireh Rain Stations

- Max level (34 m)
- Max flowrate 59.92 m³ sec⁻¹
- Average level (30 m)
- Min flowrate of 0.29 cubic meter per sec
- 56.56 m³ sec⁻¹
- Rainfall rate (mm/h) from Kaki Bukit Rain Station
- Rainfall rate (mm/h) from Lubuk Sireh Rain Station
- Lag time before flooding event in Kangar

Sharp rises of flowrate due to accumulation of rain in catchment area
Networked Sensor Fusion System: artificial intelligence

Two stage system:
1. Point Prediction: each individual node predicts rain, time and amount
2. Networked wide area prediction based on the rain dynamics, augmenting point prediction (UniSense Network)
Rain direction: Small rain-cell

- Rain guage
- River Level sensor
Networked Sensor System (UniMAP)
Rainfall Rate Prediction (6 Hours)

- Data from Malaysian Meteorological Department
- 4 Stations – 3 years of Data

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAE</td>
<td>0.044</td>
</tr>
<tr>
<td>MAPE</td>
<td>1.93%</td>
</tr>
<tr>
<td>RMSE</td>
<td>0.048</td>
</tr>
<tr>
<td>Accuracy</td>
<td>98.06%</td>
</tr>
</tbody>
</table>
Rain at one station in river catchment and impact on river flow rate

Time units of 5 mins intervals

Flow Rate Jarum
Rainfall Padang Besar
River Flow Rate Prediction – 4 hrs in Advance
Model 1: Flow Rate Model for River Pelarit using LM Training Algorithm
River Pelarit

River Pelarit Comparing Measured and Forecasted River Flow Rate (Oct 2010)

River Flow for River Pelarit using BR Training Algorithm
**River Pelarit Prediction**

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Prediction Period Hours</th>
<th>Performance Measurement</th>
<th>MAPE</th>
<th>RMS</th>
<th>Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12</td>
<td></td>
<td>0.0190983</td>
<td>0.0598233</td>
<td>0.99976</td>
</tr>
<tr>
<td>2</td>
<td>24</td>
<td></td>
<td>0.0162268</td>
<td>0.0605847</td>
<td>0.99991</td>
</tr>
<tr>
<td>3</td>
<td>36</td>
<td></td>
<td>0.0133005</td>
<td>0.0740886</td>
<td>0.99995</td>
</tr>
<tr>
<td>4</td>
<td>48</td>
<td></td>
<td>0.00893405</td>
<td>0.108714</td>
<td>0.99998</td>
</tr>
<tr>
<td>5</td>
<td>60</td>
<td></td>
<td>0.00953192</td>
<td>0.203671</td>
<td>0.99999</td>
</tr>
<tr>
<td>6</td>
<td>72</td>
<td></td>
<td>0.00749052</td>
<td>0.221873</td>
<td>0.99991</td>
</tr>
<tr>
<td>7</td>
<td>84</td>
<td></td>
<td>0.0278731</td>
<td>0.750797</td>
<td>0.99973</td>
</tr>
<tr>
<td>8</td>
<td>96</td>
<td></td>
<td>0.0464845</td>
<td>2.15264</td>
<td>0.99853</td>
</tr>
<tr>
<td>9</td>
<td>108</td>
<td></td>
<td>0.0396918</td>
<td>1.90653</td>
<td>0.99884</td>
</tr>
<tr>
<td>10</td>
<td>120</td>
<td></td>
<td>0.0580929</td>
<td>3.23307</td>
<td>0.99694</td>
</tr>
<tr>
<td>11</td>
<td>132</td>
<td></td>
<td>0.744023</td>
<td>22.1169</td>
<td>0.89261</td>
</tr>
</tbody>
</table>
Evolutionary Robotics and Artificial Intelligence

“I’m worried that I’ll be replaced by a Human”

Psychologist
For worrying robots

Drawing by Dr Barry Haynes
Concluding Remarks

• What problem are you solving?

• Who and how many people will benefit?

• What is nature doing?

• ?
Thank you!
Any questions?

Questions?

[Image of a cartoon scene with a speaker pointing at a board, a audience member yawning, and a person taking notes.]

david.ndzi@uws.ac.uk

Image from slides by Carlo Boano
Acknowledgements

• University of Malaysia Perlis
  – Dr Munirah Kamarudin
  – Dr Ammar Zakaria

• Malaysian Meteorological Office

• My former PhD Students:
  – Dr Noor Zuraidin Bin Mohd Safar
  – Dr Hassanuddin Mohamed Noor
  – Dr Guangguang Yang

• University of Portsmouth
Thank you

Any questions?

david.ndzi@uws.ac.uk