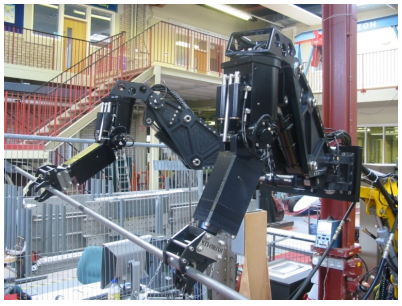
Closed-Environment Growing Systems

Micro-climate modelling, control
and energy optimisation

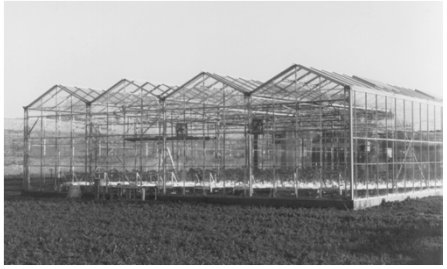
James Taylor

Lancaster University

http://www.lancaster.ac.uk/staff/taylorcj







2

Contents

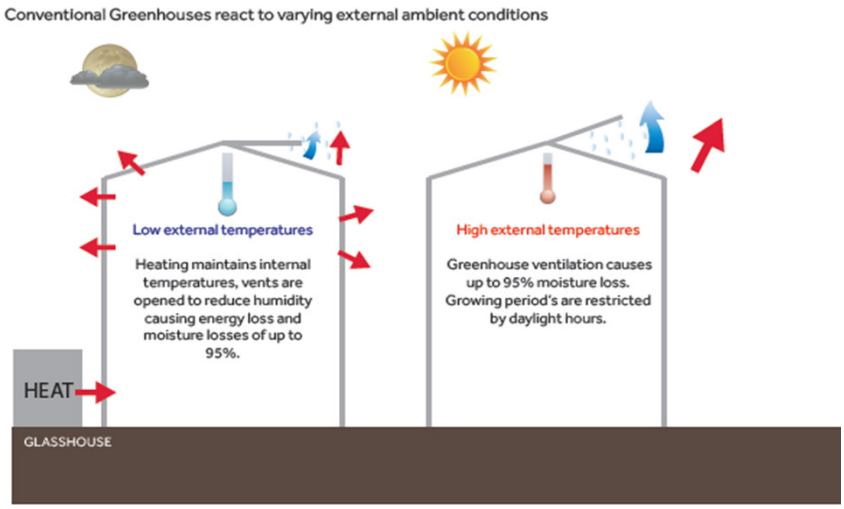
- **Part 1**: Grow cell concept
- **Part 2**: Our prototype
- **Part 3**: Some modelling

NP STRUCTURES
Established 1969

Centre for Global Eco-Innovation | LANCASTER UNIVERSITY | UNIVERSITY OF LIVERPOOL | INVENTYA

3

Part 1: Grow Cell concept



4

1. Sealed Environment



3. Automation



2. LED lights

5

Paignton Zoo vertical farming system

6

Grow Cell: Argued benefits …

- Flexibility to grow crops at any geographical location.
- Effective management of land usage.
- Pricing of end-product and food waste management.



7

Grow Cell: Argued benefits …

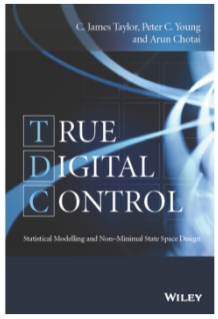
- Minimal water consumption.
- Optimal light recipes and micro-climate conditions can be used.
  - Accelerate and maximize vegetation and flowering processes.
  - Flavour and other product characteristics.
  - Control delivery date.



8

Research Challenges

- Energy consumption
- Air movement studies.
- Equipment specifications required to maintain the correct growing environment for differing crops.
- Different ways to deploy artificial lighting, stationary or moving, and the monitoring of crop reaction to these.
- Mathematical tools for the analysis of micro-climatic variables and for multivariable control system design.



9

Part 2: Our Prototype

NP STRUCTURES
Established 1969



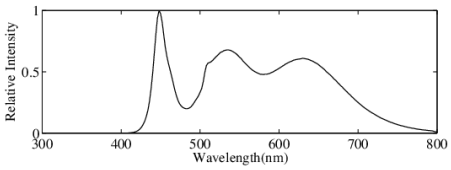
Centre for Global Eco-Innovation

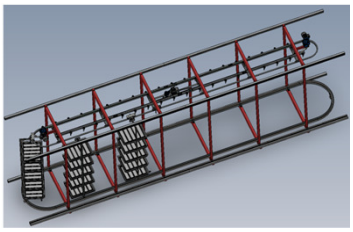
LANCASTER UNIVERSITY

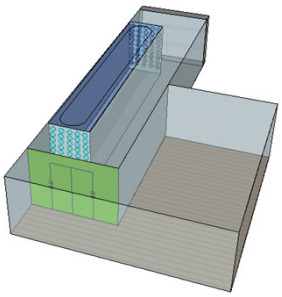
UNIVERSITY OF LIVERPOOL

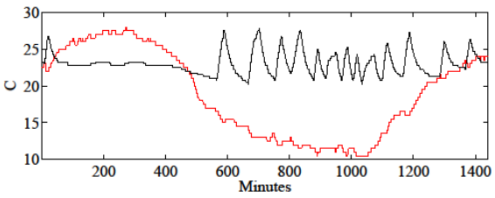
INVENTYA

10



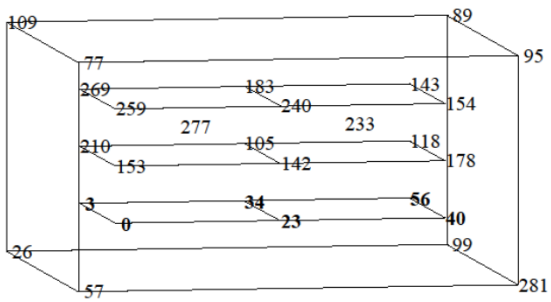






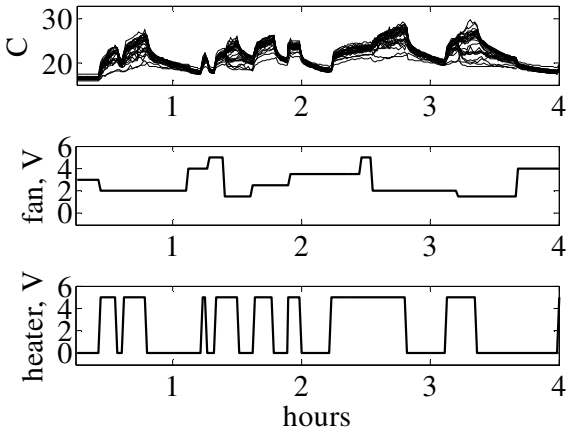
11

Correlation between each thermocouple and an illustrative reference thermocouple



12

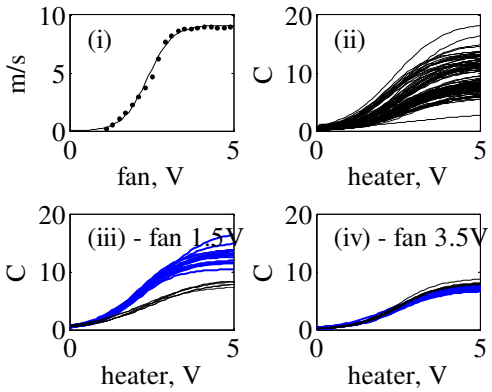
Part 3: Modelling for spatial control



Open–loop experiment showing the **temperature** from each thermocouple (upper) **fan** (middle) and **heater** (lower).

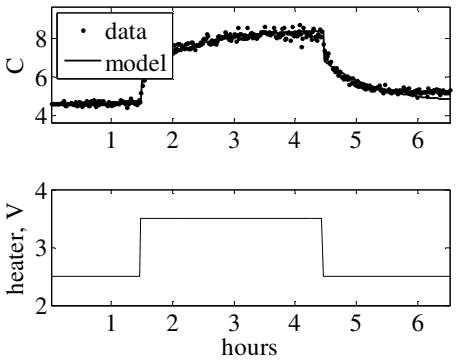
13

Steady state airflow/temperature



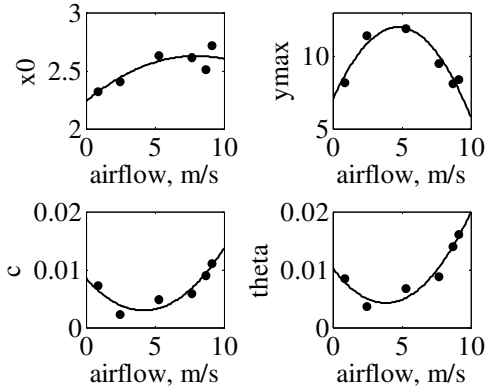
14

Simple linear model for “linear data” only



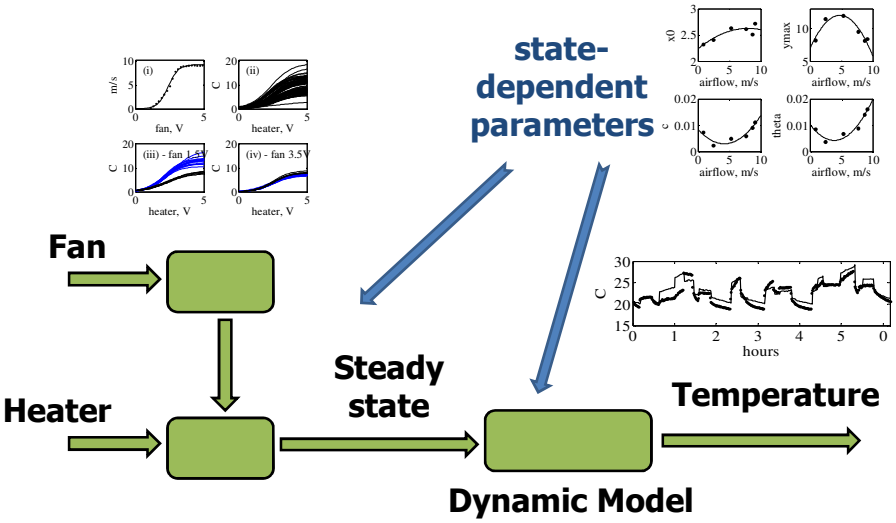
15

State dependent parameters



16

State-dependent parameter model (Hammerstein structure)



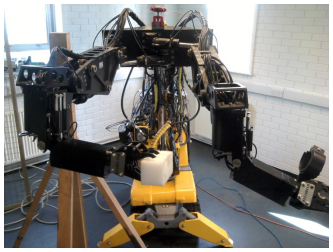
17

Conclusions

- Grow cell concept
- Prototype
- Modelling/Control







18