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Acknowledgements

I enjoyed a wonderful working relationship with my supervisors, Professor John M Counsell, Dr Nick Kelly, and Dr John Holden. I thank you all for always willing to spend time with me when I had a question or new results for discussion. I am grateful to them for the background ideas that I have contributed to this thesis and advice in formal and informal discussion sessions throughout the research period.

Particularly, I should like to thank my colleges Matt Stewart, Alastair Scot, Gavin Murphy, Obadah Zaher, Ala Hisham, James Johnston and Joseph Brindley. They helped me a lot in clarifying, communicating and analysing ideas. I learned a great deal from Joseph Brindley about the control and analysis of systems. I am very thankful for them for always being willing to spend time with me when I had a burning experimental work or a hot new experimental results to share.

The author would like to thank Professor Allan Bradshaw of the Lancaster University, for this comments and discussion relation to RIDE Control. I also want to thank all the staff in Energy Systems Research Unit (ESRU) for inputs and discussions throughout my project.

The author acknowledges the financial support derived from the BRE, BRE trust and contribution in kind from Archial group for providing case study for my project.

Publications

The following articles by the thesis author, arising from the work in this thesis, have been published.

Journal Papers

J. Counsell, Y. Khalid, J. Brindley “Controllability of Buildings A multi-input multi-output stability assessment method for buildings with **slow** acting heating systems”
Journal of Simulation Modelling Practice and Theory, Elsevier, Volume 19, issue 4
April 2011, pages 1185-1200

Conference Papers

J. Counsell, Y. Khalid “Controllability of Buildings: A multi-input multi-output stability assessment method for buildings with **fast** acting heating systems” CIBSE Technical Symposium, 6th Sept 2011, De Montfort University, Leicester, UK

J. Counsell and Y. Khalid “A Holistic Analysis method to assess the controllability of commercial buildings and their systems” SEEP 09 14 Aug conference Dublin (Sustainable Energy and Environmental Protection)

J. Counsel and Y. Khalid “Controllability of modern commercial buildings”
WRECX conference 21-25 July 08

Nomenclature

PID = Proportional Integral Differential

CAB = Climate Adaptive Building

SISO = single input single output

RIDE = Robust Inverse Dynamics Estimation

MIMO = multiple inputs and multiple outputs

MV = Mechanical Ventilation,

NV = Natural ventilation

PSV = Passive stack ventilation

A - Area (m^2) NOTE: A with subscript is defined as area. In some places in the thesis, Capital A without subscript is defined as a matrix. This is the A matrix for the linearised model of the building which is represented in the state space form.

b – Number of occupancy

c_p – Specific heat capacity (J/kgK)

C_D – Discharge coefficient of vent opening

C_v – Effectiveness of openings (C_v is assumed to be 0.5 to 0.6 for perpendicular winds and 0.25 to 0.35 for diagonal winds)

d – Differential operator

G – Heat generation rate per person (kg/s)

G – Gravitational acceleration (m/s^2)

ΔH – height difference between upper and lower vents (m)

h – Convective heat transfer coefficient (W/m^2K)

I – Solar radiation (W/m^2)

j – Represents the j^{th} element i.e. number of wall in range 1-4

k – Constant of proportionality

k_e - Proportion of light power converted to heat

L – Lux

n – Air change rate (s^{-1})

P – Electrical power into lights (W)

\dot{Q} – Heat transfer rate (W)
q – Volume flow rate (m³/s)
 s_x – switching surface for sliding mode
s – laplace variable
T – Temperature (K)
t – Time (s)
U – Heat transfer coefficient (W/m²K)
V – Volume (m³)
 v – Wind speed (m/s)
W – Humidity (vapour) transfer rate

Symbols:

ρ - Density of (kg/m³)
 α – Fraction of total transmitted solar gain through the window that goes into the element such as wall, mass etc.
 σ – Transmissivity (determines the total transmitted solar gain through the windows)
 ε – Emissivity of the plant
 λ – Daylight factor
 τ – time constant

Subscripts:

1,2,3,4 - Wall numbers
a – air
ap – appliances
b – Boltzmann's constant
cm – comfort
cp – convection heat transfer from plant to air
d – Internal humidity gain
dr – direct
df – diffuse

f – Floor
i – Internal
L – Lights
m – Internal mass
mv – mechanical ventilation
t – Buoyancy (thermal)
v – Wind pressure
ni – infiltration
o – External
oc – occupancy
p – Plant
pr – radiation component of the plant
pc – convection component of the plant
pp – per person
r – Roof
rp – Radiant component of plant
s – Solar
sa – Sol-air
sf – Solar radiation falling on the floor
v – Wind
w – Wall
win – Window