Diff-MAS1D/Diff-MAS2D and Wave-MAS1D/Wave-MAS2D: Simulation Platforms for Controlling Distributed Parameter Systems with Networked Movable Actuators/Sensors

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Outline of Presentation

- Introduction

- Usage summary

- Three demos: some capabilities of Diff-MAS1D/Diff-MAS2D and Wave-MAS1D/Wave-MAS2D

- Future work
What are Diff-MAS1D/Diff-MAS2D and Wave-MAS1D/Wave-MAS2D?

Simulation Platforms for Controlling Distributed Parameter Systems (Diffusion and Wave) with Networked Movable Actuators and Sensors

- The diffusion equation

\[ \frac{\partial u(x, y, t)}{\partial t} = k\left(\frac{\partial^2 u(x, y, t)}{\partial x^2} + \frac{\partial^2 u(x, y, t)}{\partial y^2}\right) + f_c(x, y, t) + f_d(x, y, t) \]

- The wave equation

\[ \frac{\partial^2 u(x, y, t)}{\partial t^2} = k\left(\frac{\partial^2 u(x, y, t)}{\partial x^2} + \frac{\partial^2 u(x, y, t)}{\partial y^2}\right) + f_c(x, y, t) + f_d(x, y, t) \]
• Why do we develop Diff-MAS1D/Diff-MAS2D and Wave-MAS1D/Wave-MAS2D ourselves?

  – MAS-net project and the related research topics need it.
  
  – No available software packages are able to do it.

• Current development status.

  – Diff-MAS1D/Diff-MAS2D: version 0.9.1
  
  – Wave-MAS1D/Wave-MAS2D: version 0.8
Usage summary (Diff-MAS2D)

1. Fill out five files
   - initialization.m: top-level parameter initialization
   - actrl.m/sctrl.m: actuator/sensor movement control algo.
   - dpos.m: disturbance movement description (open-loop)
   - controller.m: diffusion process control algorithm

2. Run simstart.m

3. Post-process
Demo one: moving disturbance tracking, actuator/sensor movement control, and diffusion control (Diff-MAS2D)

- How to track a disturbance?

- How to control the movement of actuators and sensors?

- How to do diffusion control?
Initial layout

- initial actuator positions
- initial sensor positions
- Neumann boundary conditions
- disturbances
Let’s watch movie.
Demo two

Part one: a disadvantage of collocated actuator/sensor scheme (Diff-MAS2D)

- Collocated actuators/sensors: making it hard to measure gradient and track disturbance

- Why it works in Demo one?

- Let’s add noise to sensors.
Movie clip
Demo two  part two: a solution

- Leader-follower scheme

- It is not easy!
  - What is a follower? The definition relies on the speed of the leader.
  - The speed of the leader can not always be trusted.
  - My solution.
Initial layout

- Initial actuator positions
- Initial sensor positions
- Neumann boundary conditions
- Disturbances
Movie clip
Demo three: suppressing vibration caused by an impulse disturbance (Wave-MAS2D)

- Actuators/sensors: fixed
- Control law: derivative.
Initial layout

- Initial actuator positions
- Initial sensor positions
- Dirichlet boundary conditions
- Disturbances
Movie clip one: uncontrolled response
Movie clip one: controlled response
Future work

• More terms in PDEs.

• More boundary conditions for Wave-MAS1D/Wave-MAS2D.

• Nonlinear PDEs.
Thank you!

Questions or comments?