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

    $$\frac{\partial u(x,y,t)}{\partial t} = k(\frac{\partial^2 u(x,y,t)}{\partial x^2} + \frac{\partial^2 u(x,y,t)}{\partial y^2}) + f_c(x,y,t) + f_d(x,y,t)$$

  - The wave equation

    $$\frac{\partial^2 u(x,y,t)}{\partial t^2} = k(\frac{\partial^2 u(x,y,t)}{\partial x^2} + \frac{\partial^2 u(x,y,t)}{\partial y^2}) + f_c(x,y,t) + f_d(x,y,t)$$

- 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

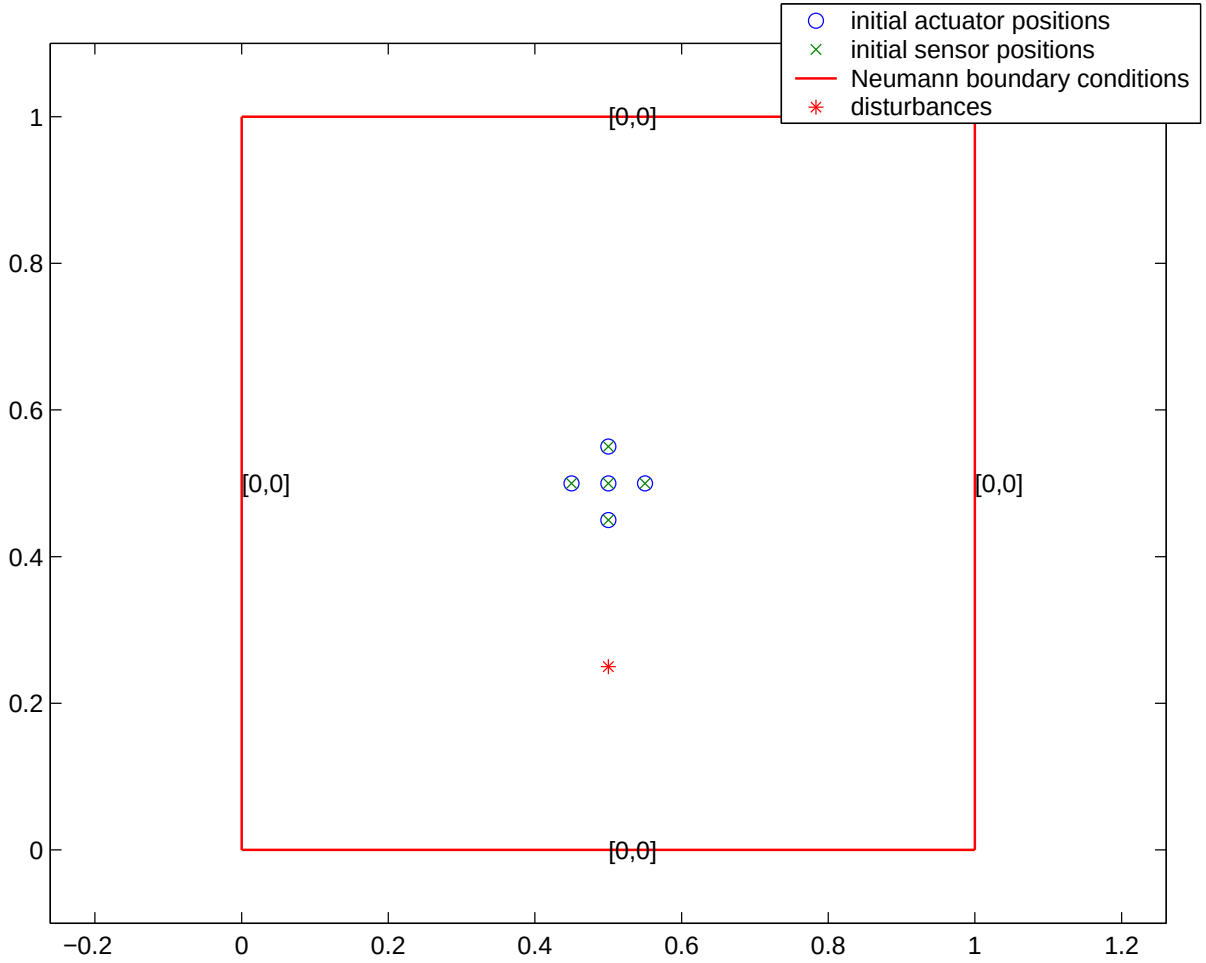
Usage summary (Diff-MAS2D)

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



Let's watch movie.

Demo two

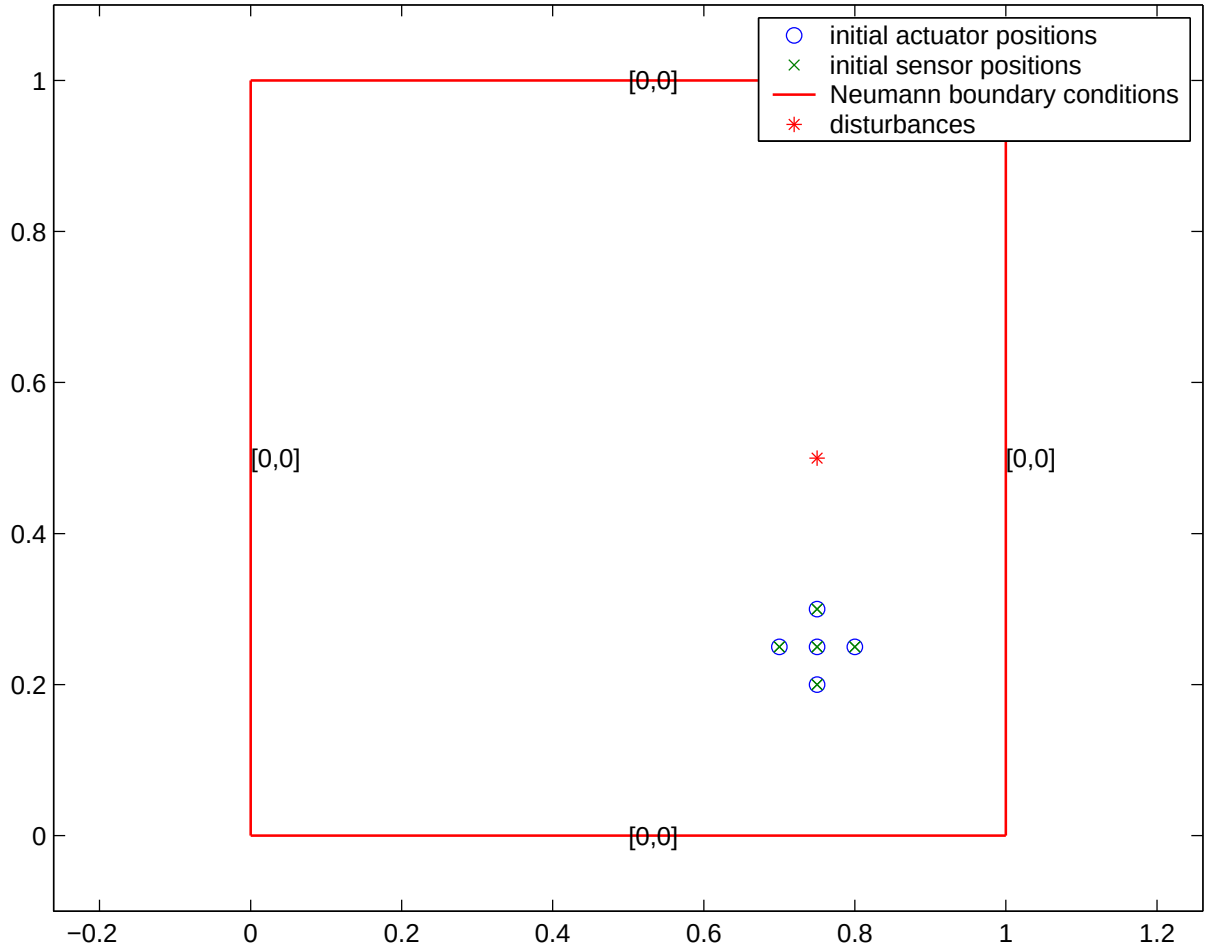
Part one: a disadvantage of collocated actuator/sensor scheme (Diff-MAS2D)

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

- Why it works in Demo one?

- Let's add noise to sensors.

Initial layout



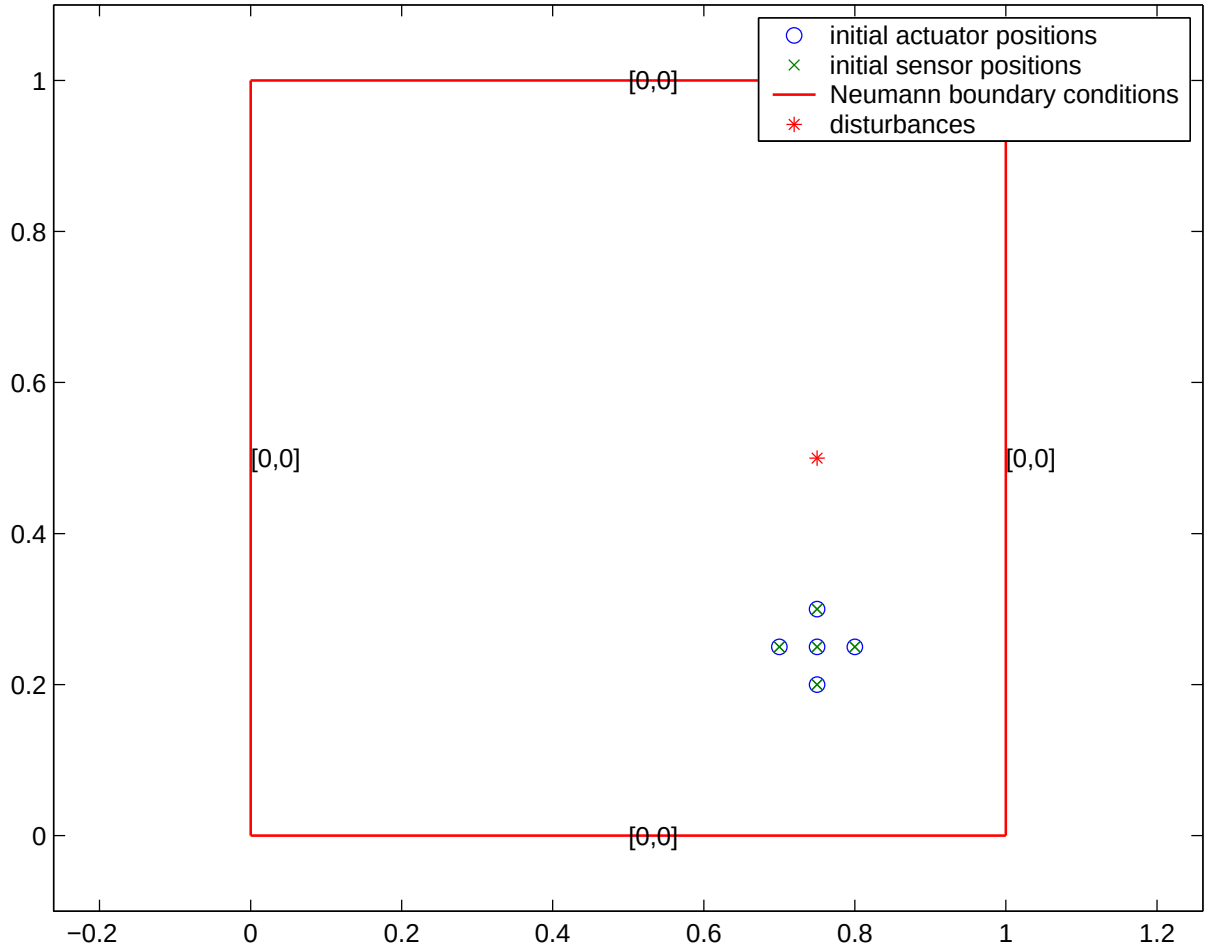
Movie clip

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



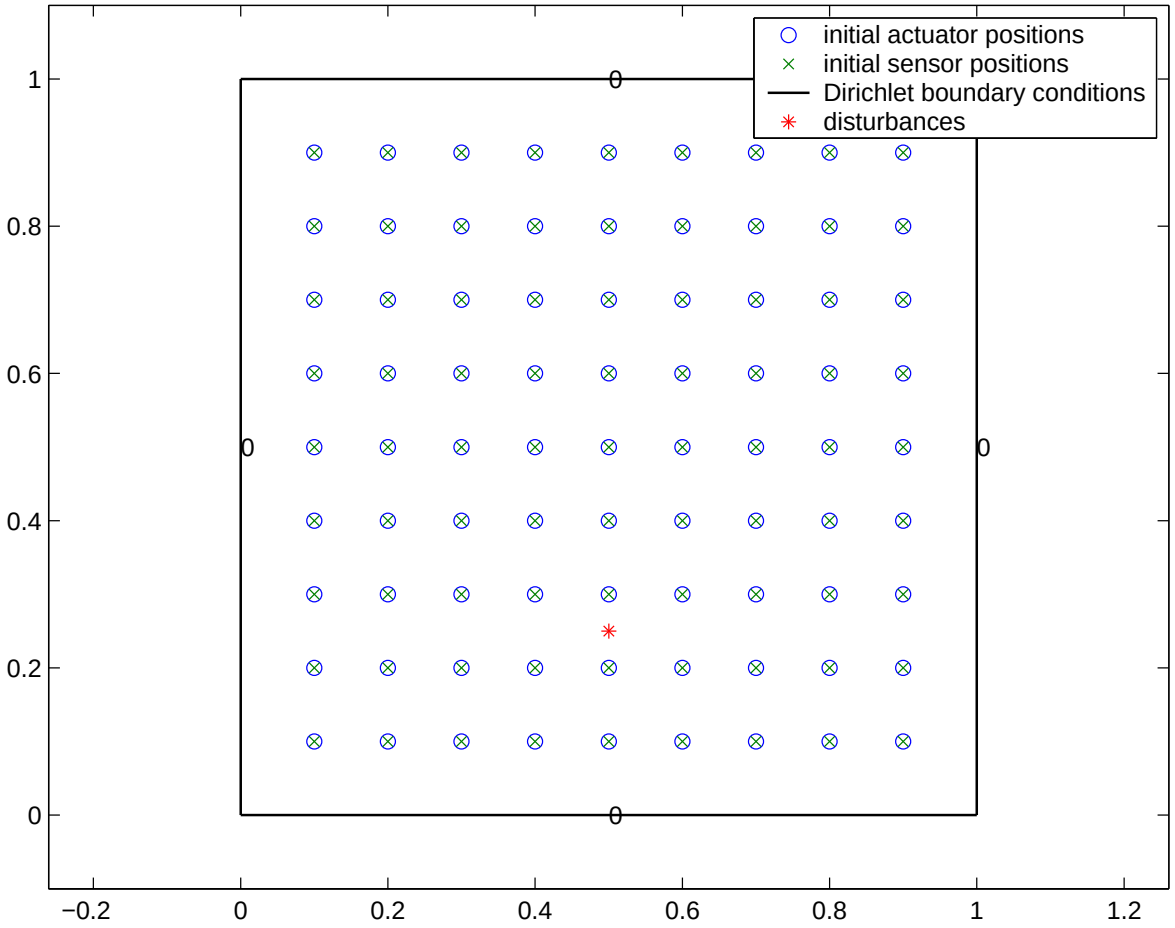
Movie clip

Demo three: suppressing vibration caused by an impulse disturbance (Wave-MAS2D)

- Actuators/sensors: fixed

- Control law: derivative.

Initial layout



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?