Market Based Control(Maja Karasalo, 21th June 2006)

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Articles

- Distributed Allocation Using Analog Market Wire Computation and Communication: W. Jackson, C. Mochon, K. Schuylenbergh, D. Biegelsen, M. Fromherz, T. Hogg and A. Berlin.
- Air Jet Paper Mover: D. Biegelsen, A. Berlin, P. Cheung, M. Fromherz, D. Goldberg, W. Jackson, B. Preas, J. Reich and L. Swartz.

Properties of Market Based Control

- Market:system with locally interacting components that achieve some global behaviour together.
- Simple interactions(trading):global effects (stable, prices, fair allocation, etc.)
- Often not optimal solution guaranteed, but satisfactory results for large systems.
- Very little global info needed (only price)–good for complex problems, scalable.
- Parameters of model:communication paths, efficiency of communication, accuracy of communication, time delay of communication.
- Weakness of model:hard to estimate/measure parameters that yield a desired behaviour.
- Advantage:decentralized control (no single agent) needs to know all parameters model.
- Output:a product/service desired, value of product/service.
- Distributed allocation using analog market wire computation and communication.

Market based control is used for allocation of actuation among large numbers of analog electronic air jet controllers.

Applications (Motivation)

A sheet of paper is transported or contained in a closed space without touching walls, levitating on jets of air (i.e. transporting sensitive coated paper, save energy by not using rollers).

Market Allocation

A number of agents act on a market. The problem of allocation of tasks is solved by agents bidding for pains of the total task (total task determined by higher level control). The behaviour of each agent depends on local info and global market price, while requirement of minimal communication and of robust against failure of individual agents.

Implementation

- Control of linear(1D) movement and angle of a set of paper by using an air jet table.
- System–many valved air jets controlled by actuators.
- The market solves the problem of which valves to open and close to deliver a desired aggregate force F_d and torque T_d

$$\begin{aligned} F_d &= \Sigma f_i + \Delta F \\ T_d &= \Sigma x_i f_i + \Delta T, \end{aligned}$$

where x_i : position of actuator i relative to center of mass, and $f_i = \{-f, 0, f\}$: force from actuator i, shown in Fig.1 and Fig.2.

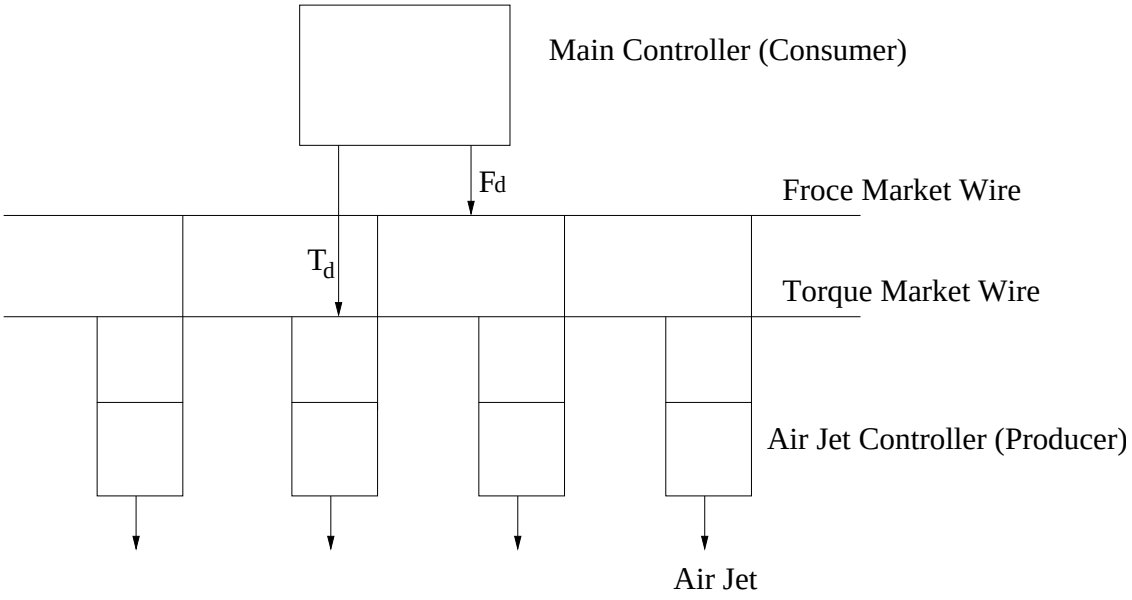

Figure 1: System Description

Trading process

- Consumer adds F_d to force market and T_d to torque market.

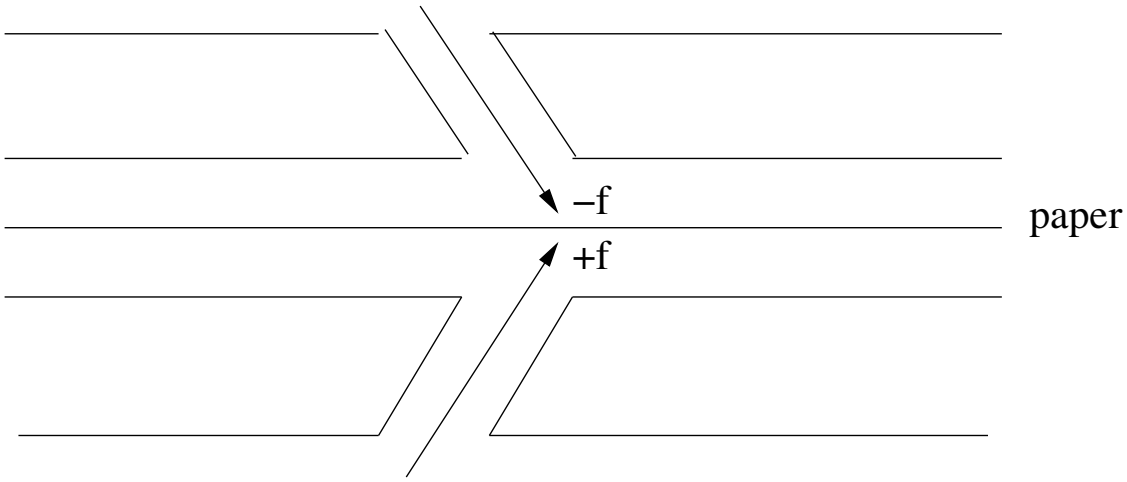

Figure 2: Air Jet

- Producers measure voltage in wires—markets and compute prices P_F and T_F

$$P_F = \int \Delta F dt/C, \quad T_F = \int \Delta T dt/C$$

→ the voltage in each wire represents the price of the product sold on the corresponding market.

- The weight of force and torque prices depend on position of the actuator relative to c.m. More weight on torque close to the edge.
- Utility function computed by each controller,

$$u_i = P_F + x_i P_T.$$

If u_i lies below a threshold

$$\rightarrow f_i = -f.$$

If u_i lies above a threshold

$$\rightarrow f_i = +f$$

If in between

$$\rightarrow f_i = 0.$$

- Goal is reached, if when the paper has reached its new position. Each agent produces average actuation proportional to the average current added to the market wire.

Results

- Add a spike in consumer current → market stabilizes a few ms using 6 actuators.
- Adding — removing actuators → same results.