Cyber-Physical Systems for Material Handling

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Material Handling?

“From raw material to finished goods”

_Economic standpoint:_
The logistics side of material handling already accounts for $1,300,000,000,000 (8.5% of GDP in the US) and handles 18,000,000,000,000kg of materials and goods valued at $16,000,000,000,000 per year.

_Technical standpoint:_
A wide range of involved problems in material handling (for example, assembling or grasping parts) can be addressed by cyber-physical systems (CPS) approach: physical plant + control algorithm.
Material Handling - Proposed Research

For the “Material” side:
*Autonomous Robotic Assembly*

One important issue here is the **feasibility** of the resultant assembly plan.

An intermediate state that can be problematic

The intermediate state eventually results in peg-in-hole assembly that can be tricky

A target shape

For the “Handling” side:
*Autonomous Robotic Grasping*

One important issue here is the **stability** of the resultant grasp.

A planar grasp in a stable equilibrium on the triangle by the three point end-effectors

A planar grasp not in a stable equilibrium on the triangle by the three point end-effectors
Material Handling – Our Approach

For the “Material” side:

*Autonomous Robotic Assembly*

- Identical, modular building blocks docked in a common brick wall pattern

- LEGO-style docking
  - common brick wall pattern that is geometrically complete and structurally sound

- Assembly planning for feasibility
  - free of peg-in-hole assembly scenarios
  - further supports distributed assembling

For the “Handling” side:

*Autonomous Robotic Grasping*

- Effector with concavity
  - All objects can be immobilized and caged by at most three concave effectors shown above.

- Grasp planning for stability
  - no need for instantaneous situational awareness.

Two examples of target shapes

Two examples of target grasps
Potential Impacts on Research and Industry

- Wearable Robot
  - Beattie et al.
- Bacteria-propelled sys.
  - Wong et al.
- Self-assembly
  - Eckenstein et al.
- Healthcare
- Manufacturing
  - Eckenstein et al.
- Outer space
- Aerial, Dynamic grasping by quadrotor
  - Thomas et al.
- Disaster response
- Military