Research collaboration of large scaled tunable impedance device toward variable stiffness actuator

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Agenda

- Greeting
- Introduction of Collaboration
- Introduction of BDML(Biomimetics and Dexterous Manipulation Lab)

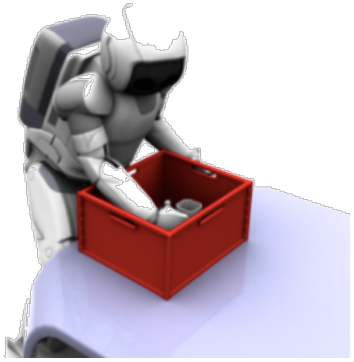
  And possible solution for our target.
- Summary and declaring kick-off

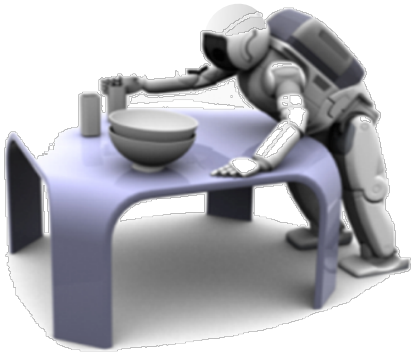
Background

Honda realized walking and a few handling Manipulation by using position based rigid robot

Our Target is

Working and Assisting with physical interaction in Human Life





Compliant Robot is essentially needed to realize this!!

Purpose

Demand 1

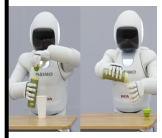
Robot should allow unexpected collision in coexistence with human or hazardous environment

Robot needs **Softness**

Robotics **Joint Softness** is inevitable to allow higher disturbance

Demand 2

Robot should move or work precisely in coexistence with human or hazardous environment



Robot needs **Accuracy of Move**

Robotics **Joint Rigidity** is inevitable to move with suppression of disturbance

”Softness” and “Accuracy of Move” are contrary characters and can not be realized simultaneously

Changeable Stiffness of Robotic Joint according to situation

Robotic actuator with variable stiffness

Purpose

We realize Robotic Actuator with variable stiffness for robot to allow Unexpected collision and to do still accurate work and move.

Important Factors

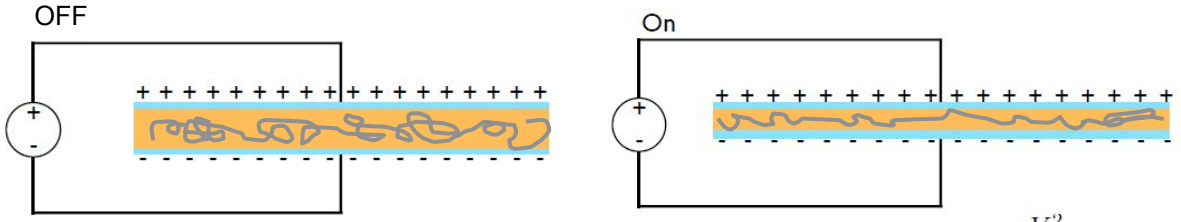
Purpose

We realize Robotic Actuator with variable stiffness for robot to allow unexpected collision and to do still accurate work and move.

Factors	Reasons	Target Value for Asimo's Elbo
Wider stiffness range	Compatibility of Softness and Accuracy of move	200 – 800 Nm/rad
Change stiffness in real time	Maximum force is often occurred within 50ms in experimental robot collision data	Within 50ms
Lighter weight of device	Device weight affects linearly the energy of disturbance	Within 200g (device only)
Larger deflection of stiffness	To raise up the energy absorbance while collision	7 degree

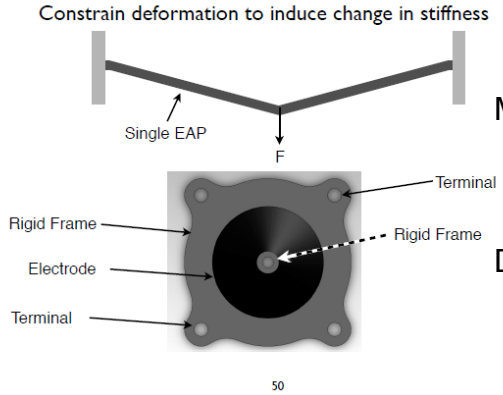
Utilizing functional material

What's EAP（Electroactivepolymer）?



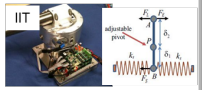
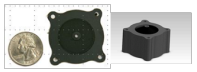
$$p = \epsilon_0 \epsilon_r E^2 = \frac{\epsilon_0 \epsilon_r V^2}{t^2}$$

Summary of variable stiffness device in Stanford
（Using Bow-like Structure）



Merits
- Rapidly stiffness change
- Wide stiffness range
- Light

De-merits
- High Voltage

	Range of Stiffness（200 – 800 Nm/rad）	Responce（within 50ms）	Deflection（7 deg）	Device weight（within 200g）
Mechanical method（leverage） 	0-∞ Nm/rad	800ms	15deg	Whole 1.5kg
Functional Material（MRE）金沢工業大学 	975-1949N/m	Several Hms	1mm/20mm	Device 0.6kg
Functional Material（EAP）Stanford 	15-102N/m	Several ms	8mm/80μm	Device 0.2g

EAP has potential for variable stiffness device though there are no robot applications

Subject toward robotic application

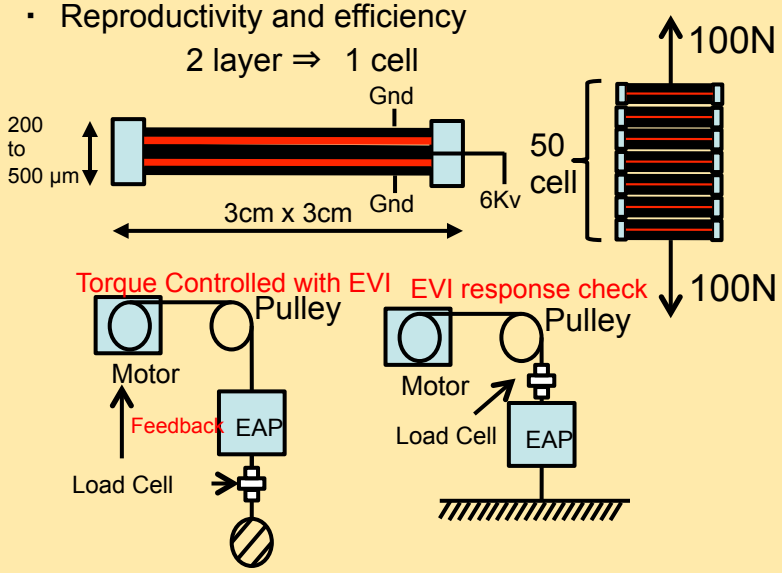
Without spoiling the merits of EAP we should realize smaller, lighter device able to endure much larger force. That is "Multi-layered EAP".

Research Steps

Step 1 Research Subject

Multi-Layered EAP for variable stiffness device

- Larger allowable force in 1 cell
- Lighter and Smaller design
- Reproductivity and efficiency



＜Validating items＞

- How different between design and experiment
- Ability of reproductivity and mechanical repeatability
- Usability of mechanical characteristics

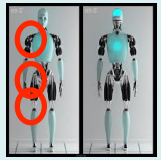
Step 2 Research Subject

2.1 Variable Stiffness Actuator for robot manipulator

- Transition to rotational move
- Realizing integrated system
- Suitable stiffness rage for robot task
- Co-actuated with main actuator

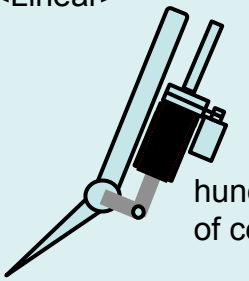
2.2 Large Torque VSA for humanoid

- 200Nm order allowable
- Super light device
  with material/electrode change
- Ensure electrical safety

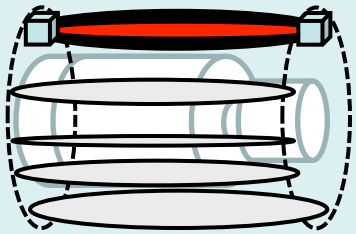


Hybrid actuator system

<Linear>



<Rotational>

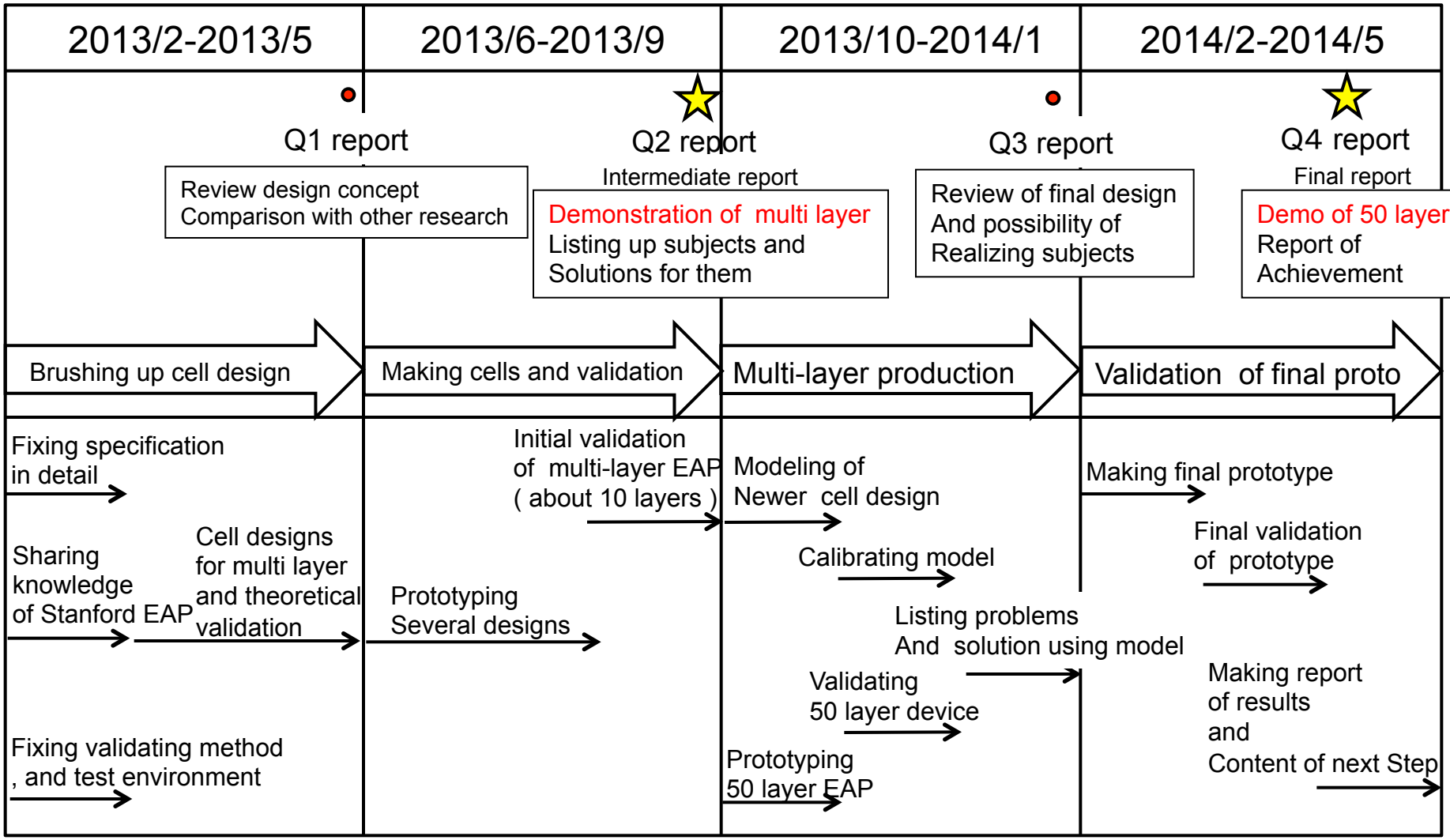


＜Validating items＞

- Force limitation of current material and design
  ⇒Listing up the needed characters of newer material
- Getting the knowledge about relation of force, volume, weight
- Listing up the design demands for electrical safety

Firstly we do Step 1, and we judge whether we do Step 2 or not according to the result.

Research Plan



Executing resources

Stanford Prof. Mark Cutkosky PosDoc

HondaR&D Atsuo Orita

Budget

About $150K / Year