Development of a Medical Tele-Analyzer for Abdominal Mass Analysis

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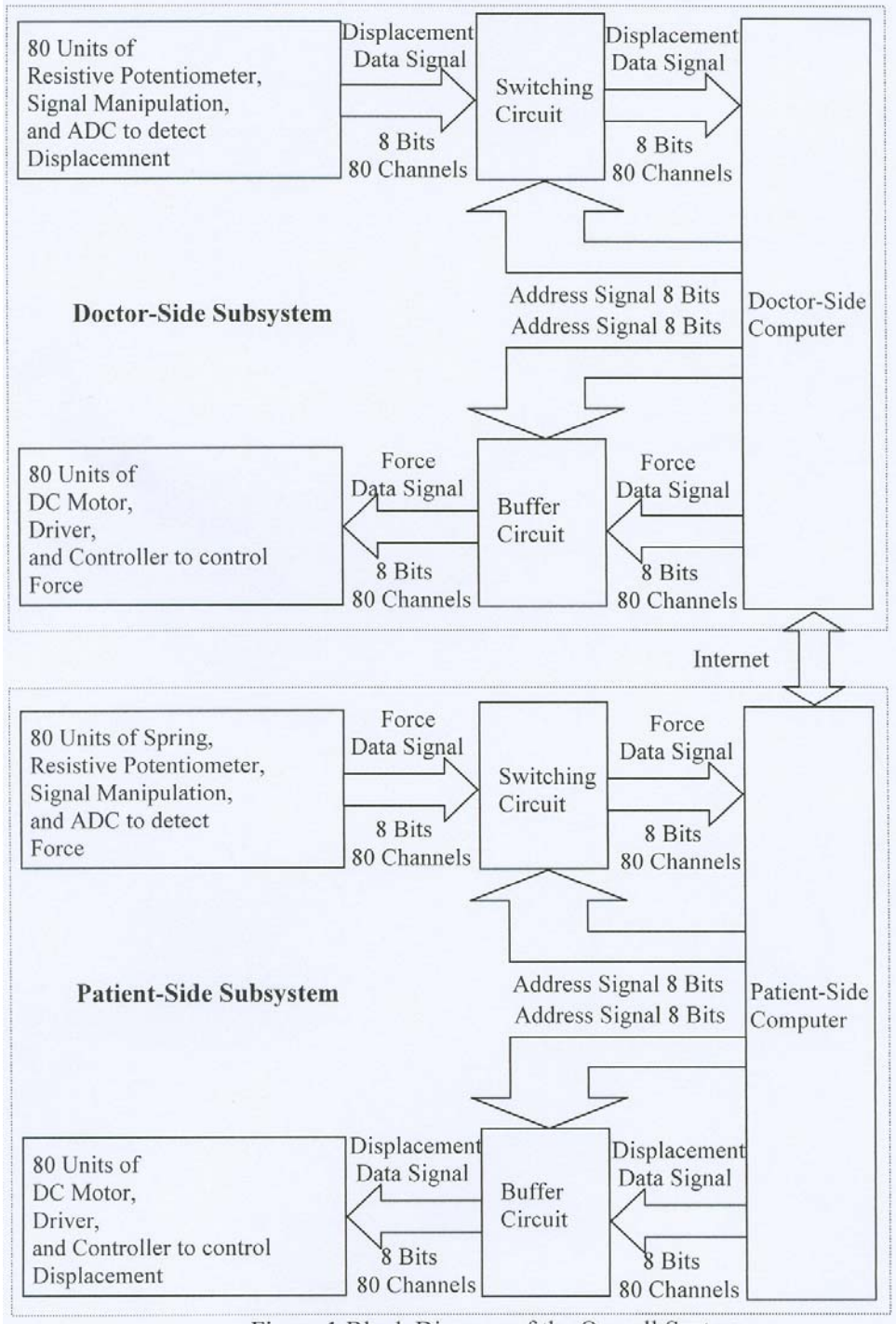
Introduction

- Among the six sensations, only visibility and audibility are transmittable.
- Transmission of tactile sensation is required.
- Tactile sensation consists of both force and displacement information.
- Medical tele-analyzer for abdominal mass analysis is developed.

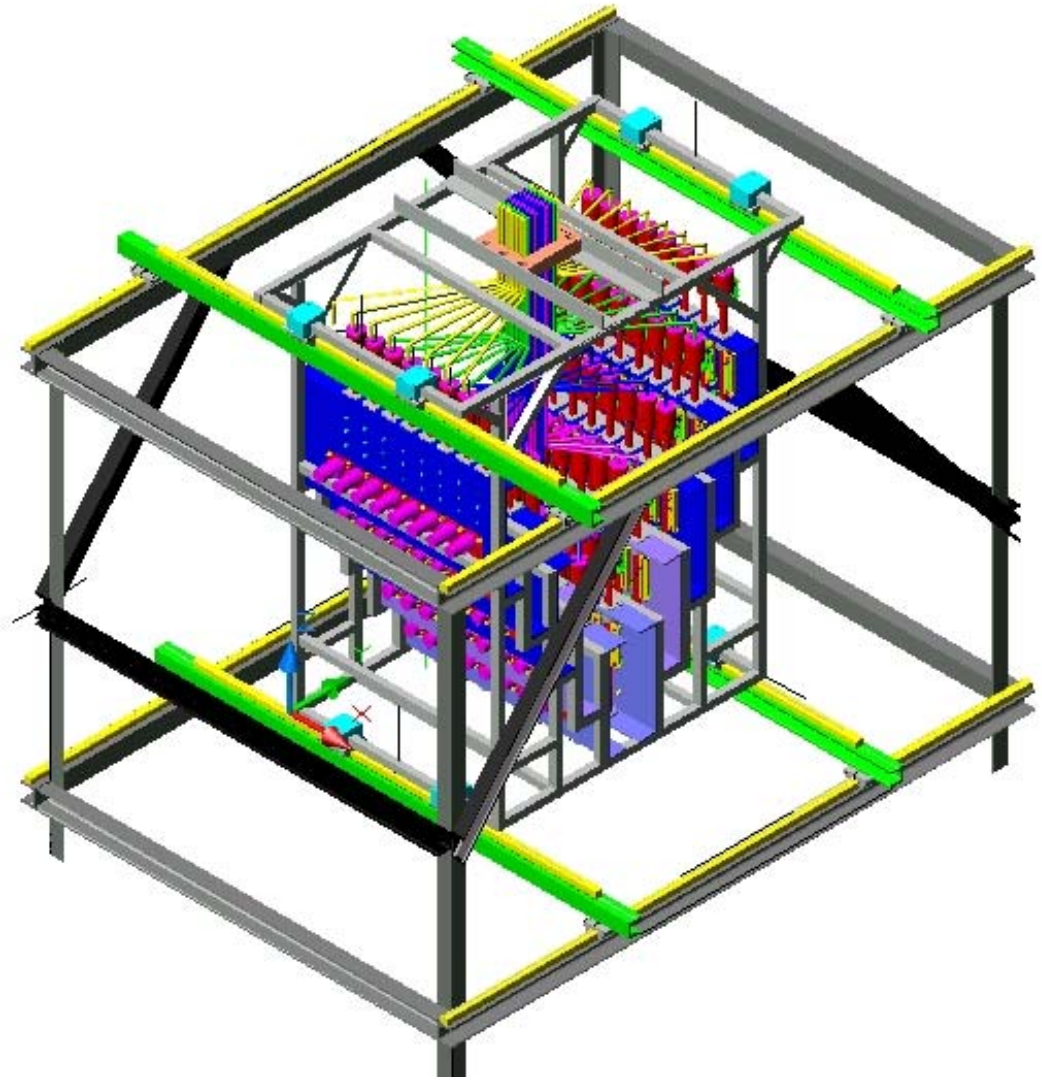
Medical Tele-Analyzer

- Used to diagnose abdominal mass
  - Hepatomegaly
  - Splenomegaly
  - Other tumors
- The system consists of 2 subsystems.
  - Doctor-Side Subsystem
  - Patient-Side Subsystem

Block Diagram of the Medical Tele-Analyzer

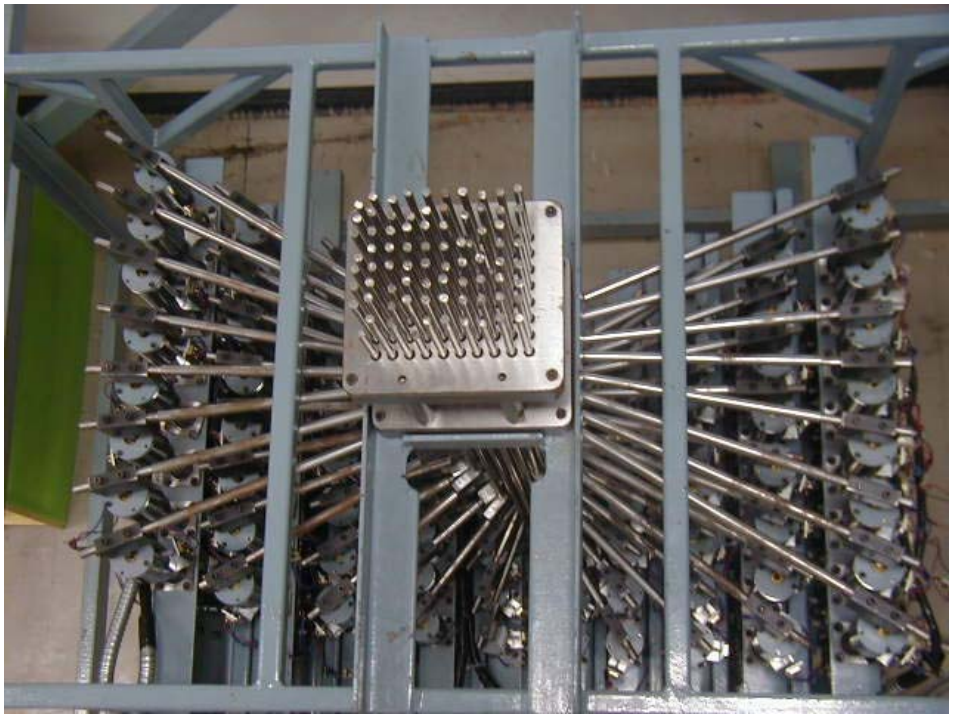


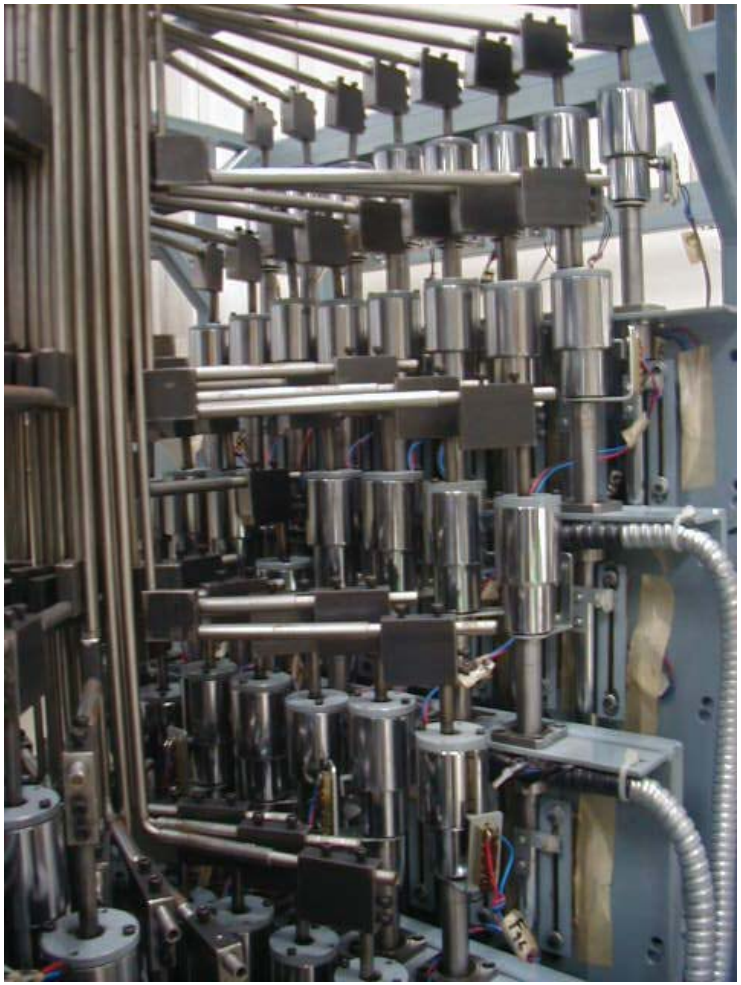
Doctor-Side Subsystem



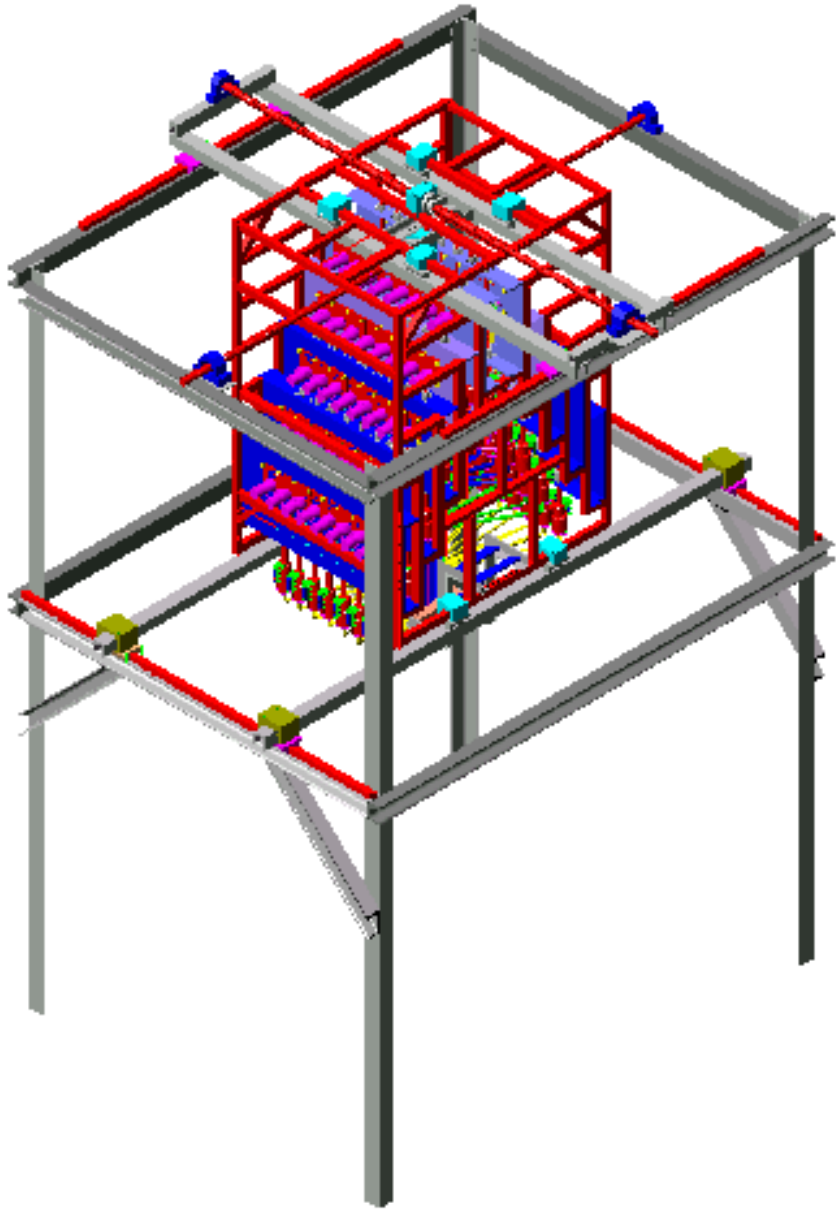
Doctor-Side Subsystem

Doctor-Side Subsystem



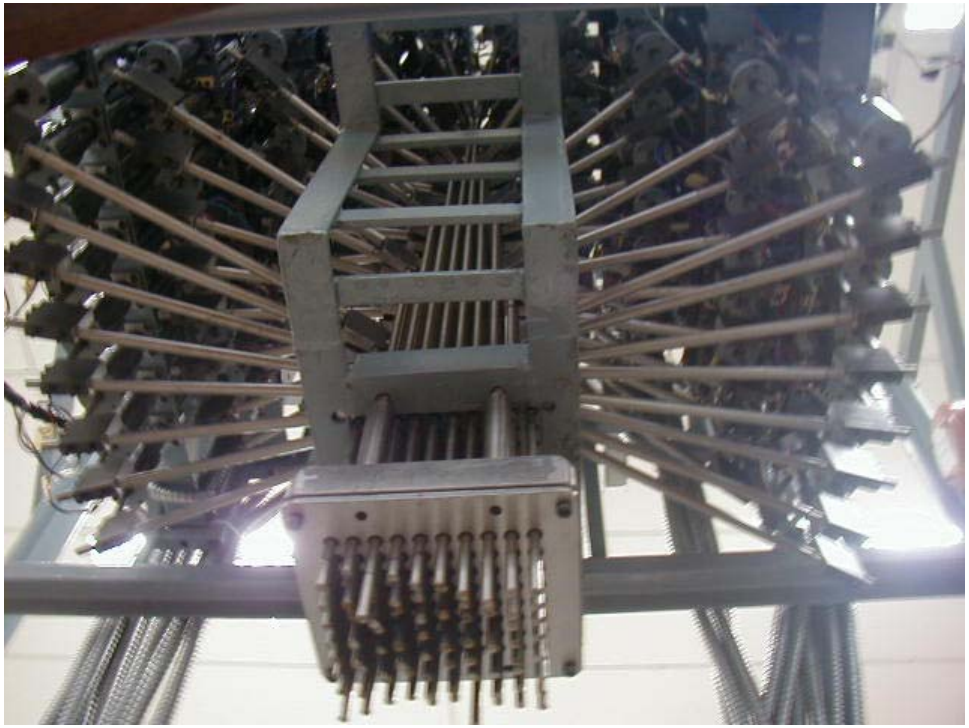


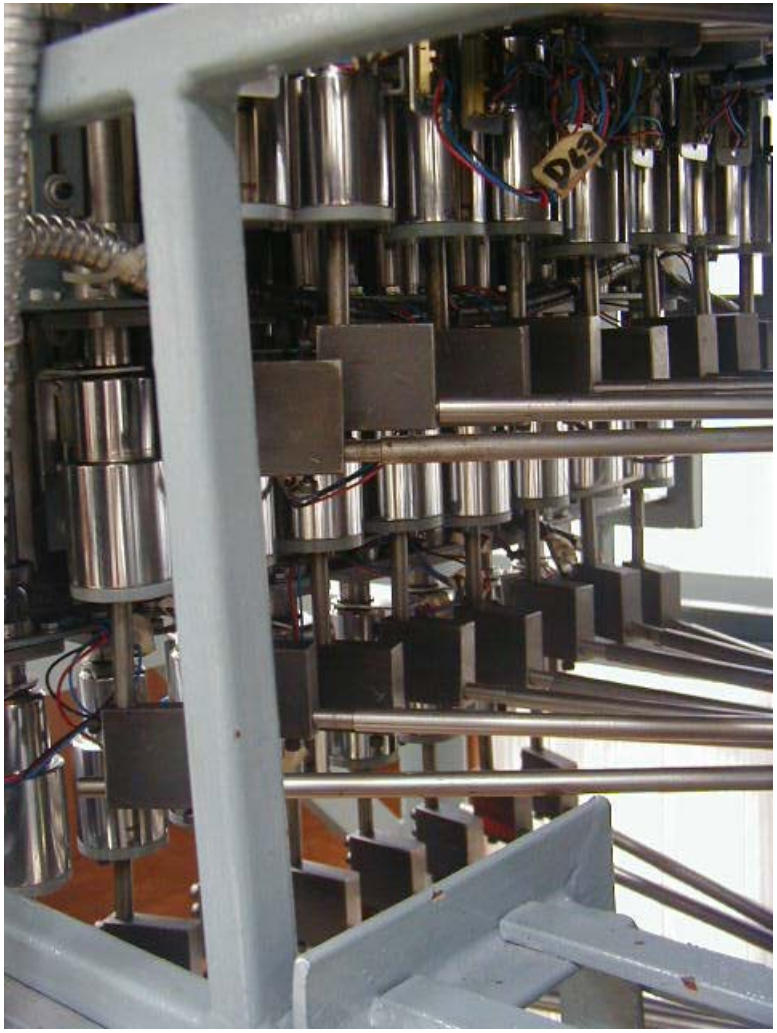
Patient-Side Subsystem



Patient-Side Subsystem

Patient-Side Subsystem





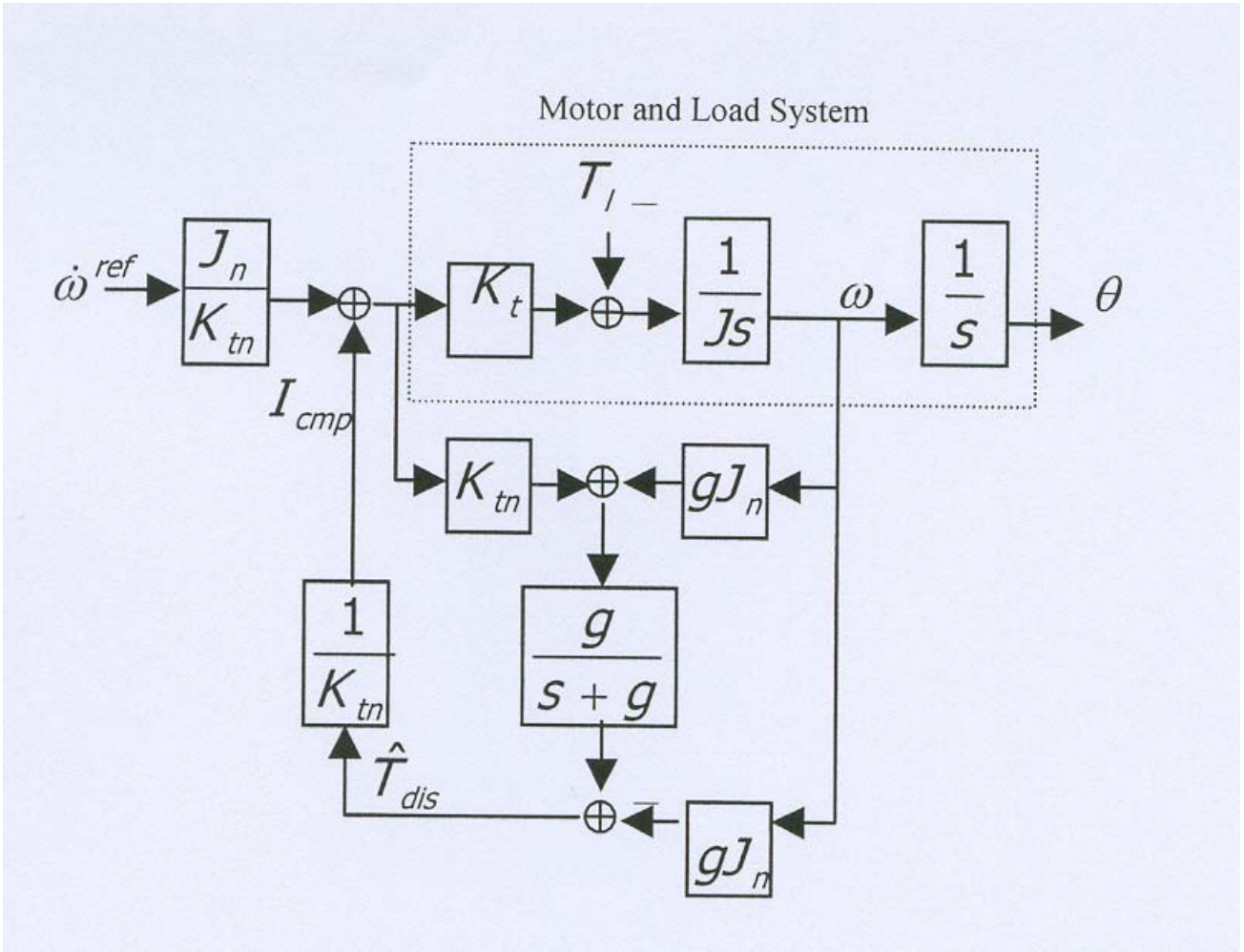
Data Collection from Hospital

- Required resolution of displacement is 2 mm.
- Required maximum displacement is 40 mm.
- Required resolution of force is 20 g.
- Required maximum force is 4725 g.

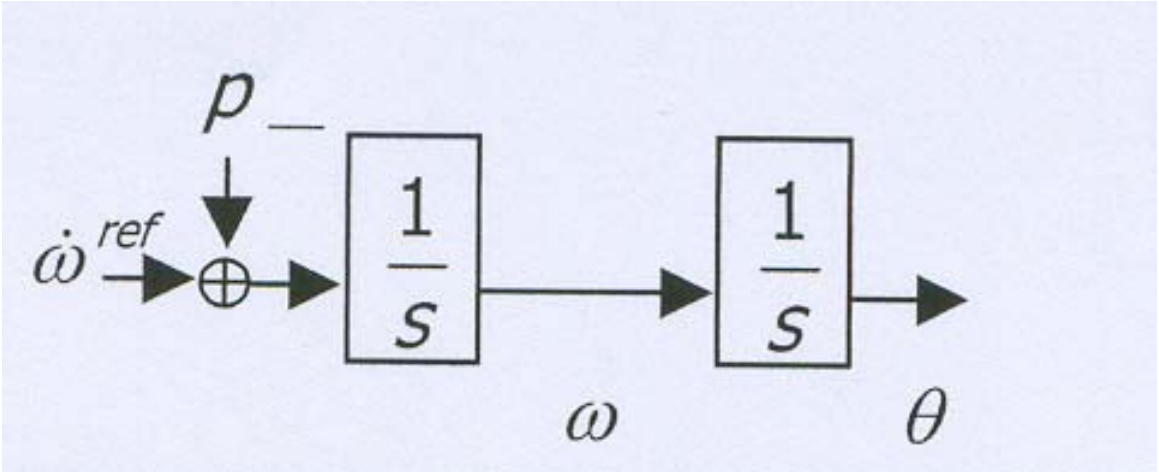
Displacement/Force Sensors and Actuators

- Resistive potentiometer is applied to sense displacement.
- DC motor is applied as displacement actuator.
- Spring with resistive potentiometer is applied to sense force.
- DC motor is applied as force actuator.

Disturbance Observer-Based Robust Motion Control



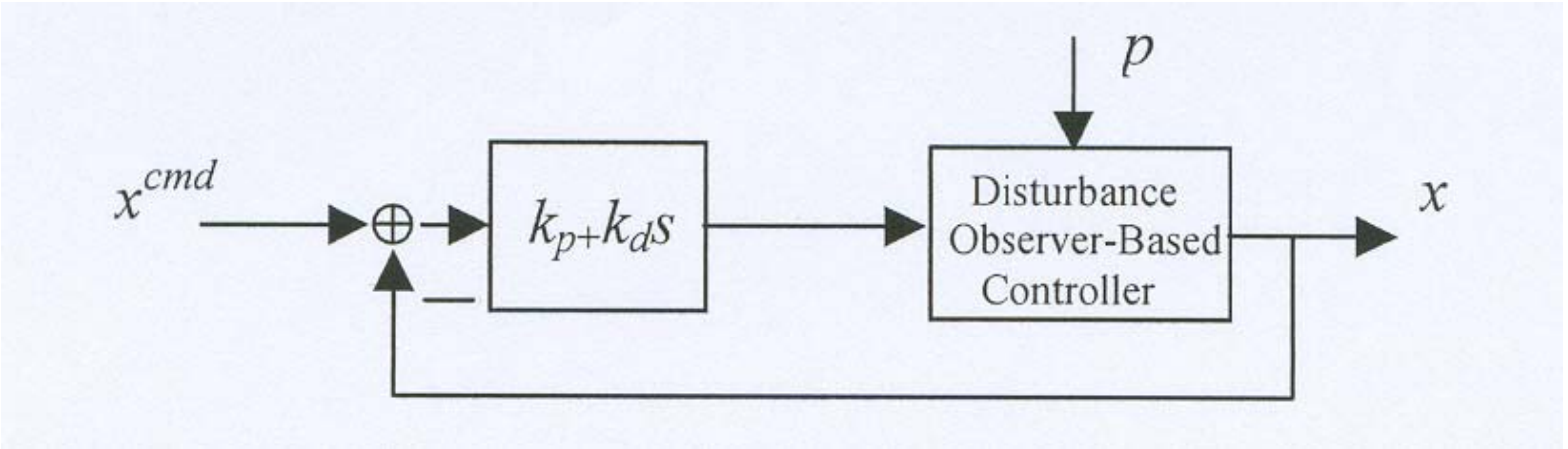
Equivalent Block Diagram of Disturbance Observer-Based Robust Motion Controller



$$p = \dot{\omega}^{ref} - \dot{\omega} = J_n^{-1} G_s T_{dis}$$

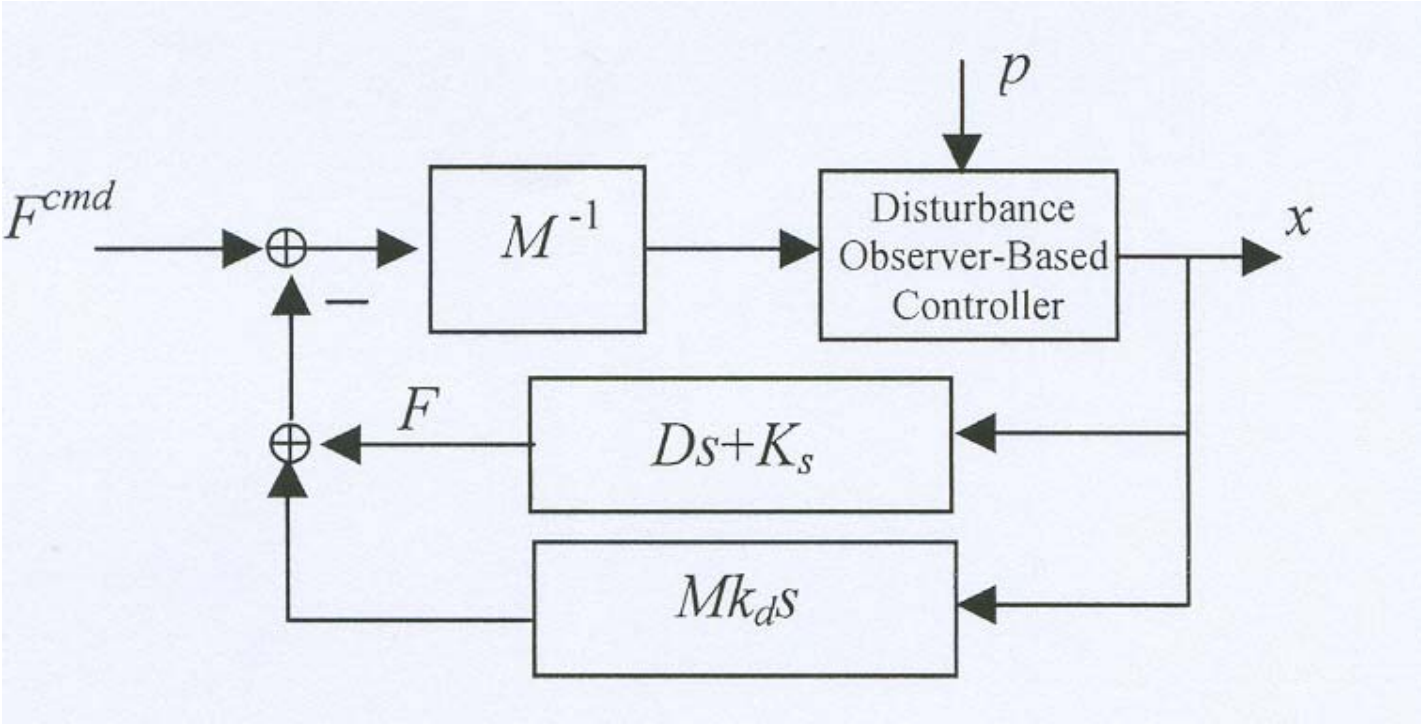
$$G_s = \frac{s}{s + g}$$

Displacement Controller



$$x = x^{cmd} - \frac{x^{cmd} s^2 + p}{s^2 + k_d s + k_p}$$

Force Controller

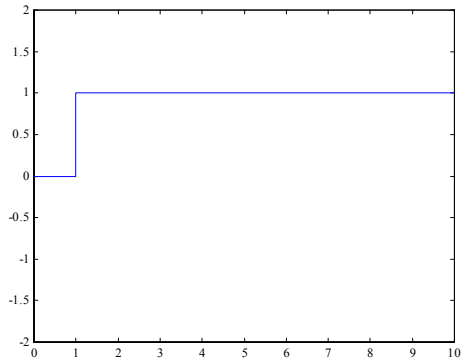


$$F = F^{cmd} - M(xs^2 + k_d xs + p)$$

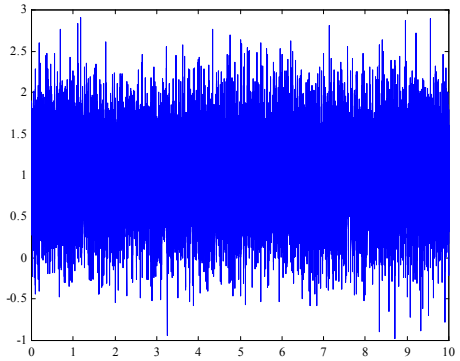
System Identification

Parameters	Description	Values	Units
J_n	Nominal Inertia	0.000254	$Kg.m^2$
J	Actual Inertia	0.0003	$Kg.m^2$
K_{tn}	Nominal Torque Constant	0.1656	N.m/A
K_t	Actual Torque Constant	0.2	N.m/A
C	Damping Constant	0.002031	N.m.s/rad
K_e	Back EMF Constant	0.982	V.s/rad
R	Armature Resistance	26.44	Ω
L	Armature Inductance	0.0138	H
M	System Mass	0.0003	Kg.m/rad
D	Damping Modulus	0	N.s/rad
K_s	Spring Constant	2.45	N/rad

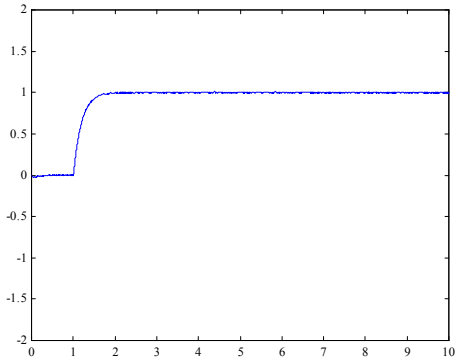
Result of Displacement Control



Displacement Command



Disturbance

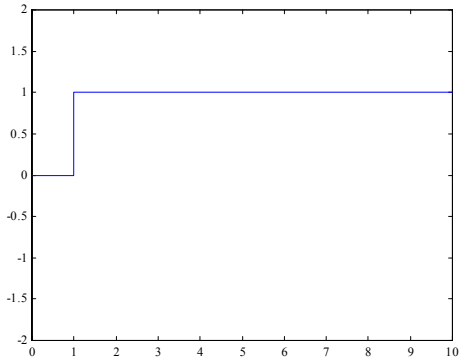


Displacement Response

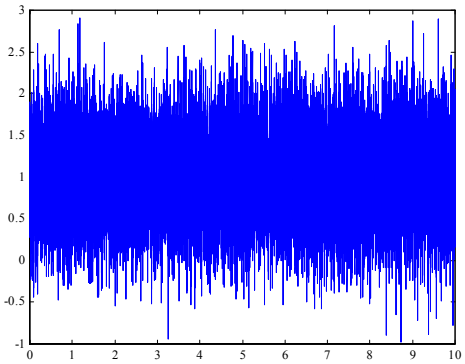
In the simulation, the gains k_p and k_d are fixed at 500 and 100 respectively. Cutoff frequency of the LPF, performed by $g/(s+g)$, is set at 1000 rad/s.

Mean of the gaussian random noise is assumed to 1 with variance of 0.25.

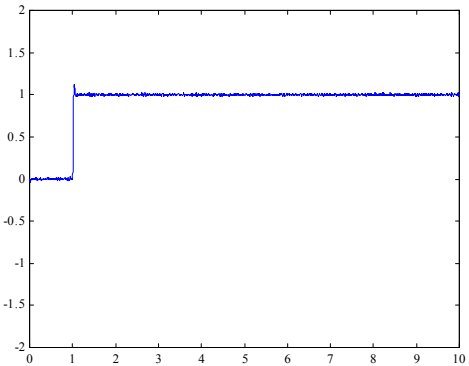
Result of Force Control



Force Command



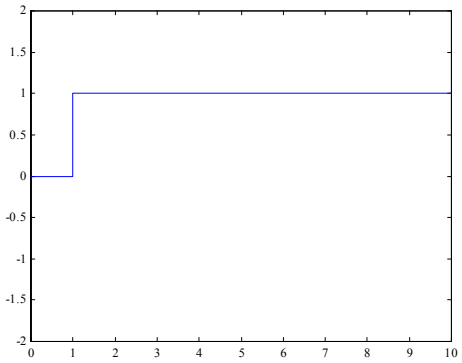
Disturbance



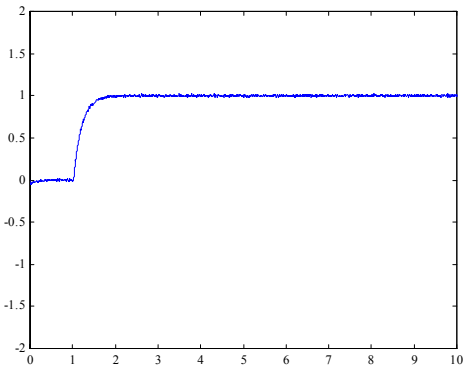
Force Response

In the simulation, the gain k_d is fixed at 100.
Cutoff frequency of the LPF, performed by $g/(s+g)$, is set at 1000 rad/s.
Mean of the gaussian random noise is assumed to 1 with variance of 0.25.

Hybrid of Displacement and Force

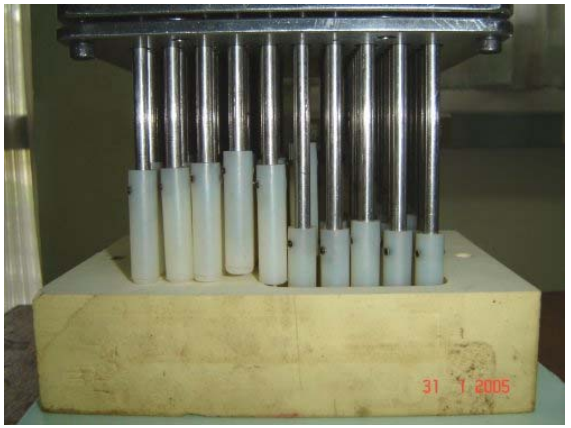


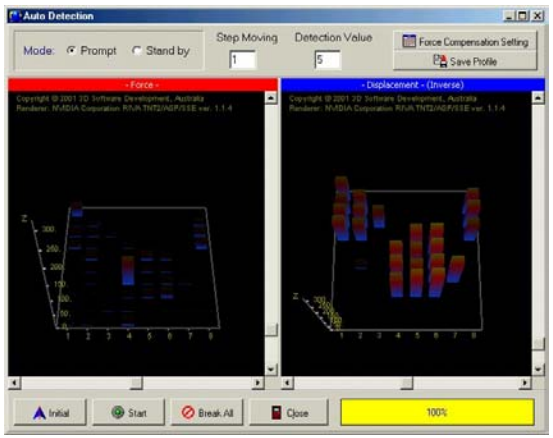
Displacement Command

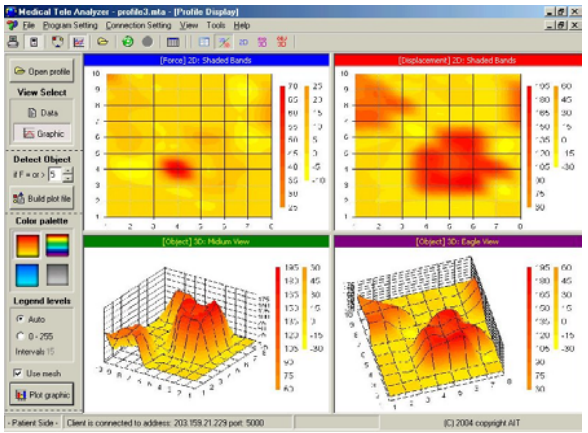


Force Response

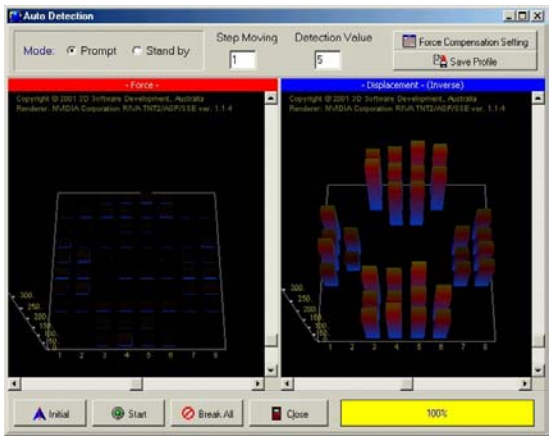
Experiment I

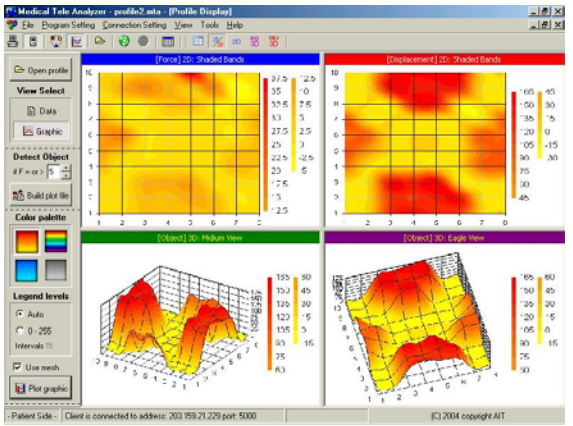






Experiment II





Conclusion

- A medical tele-analyzer for abdominal mass analysis was developed.
- Disturbance observer based robust motion control was applied to control displacement and force of the system.
- The results shown that the controller worked well even with disturbance either by parameters uncertainty or external disturbance.
- From the experiments, the medical tele-analyzer could recognize different patterns of object.
- In the future work, x-y table will be installed and more experiment on different hardness objects will be done.

Output (I)

Graduated Students

Ph.D. Anan Suebsomran

M.Eng. Veerapol Yimsinsomboon

M.Eng. Hyunh Ngoc Huy

Diploma Stefan Wortmann

Journal Paper

Anan Suebsomran and Manukid Parnichkun. "Disturbance Observer-Based Hybrid Control of Displacement and Force in a Medical Tele-Analyzer," International Journal of Control, Automation, and Systems. ICASE and KIEE. Vol. 3, No. 1, pp. 1-9 (2005)

Output (II)

Conference Papers

1. Manukid Parnichkun, Anan Suebsomran, “Development of a Medical Tele-Analyzer for Abdominal Mass Analysis.” Proceedings of the 2003 IEEE International Conference on Industrial Electronics, IECON 2003, Roanoke, USA, 2003. (Conference CD-ROM)
2. Anan Suebsomran, Manukid Parnichkun, “PID Based Control of Displacement and Force in a Medical Tele-Analyzer for Abdominal Mass Analysis.” Proceedings of the Third Asian Conference on Industrial Automation and Robotics, ACIAR 2003, Bangkok, 2003, pp. 77-81.
3. Anan Suebsomran, Manukid Parnichkun, “Disturbance Observer-Based Hybrid Control of Displacement and Force in Medical Tele-Analyzer for Abdominal Mass Analysis.” Proceedings of the 2002 IEEE International Conference on Industrial Technology, ICIT’ 02, Bangkok, 2002, pp. 365-369.

Output (III)

Conference Papers

4. Manukid Parnichkun, Watcharin Po-ngaen, and Thira Jearsiripongkul. "Development of a Force-Displacement Controlled Medical Tele-Analyzer." Proceedings of the 2001 IEEE International Symposium on Industrial Electronics, ISIE 2001, Pusan, Korea, 2001, pp. 1978-1981.

5. Watcharin Po-ngaen, Thira Jearsiripongkul, and Manukid Parnichkun. "Development of Force-Displacement Hybrid Controlled System for Industrial Tele-Monitor and Control." Proceedings of the 2000 International Conference on Production Research, ICPR 2000, Bangkok Thailand, 2000. (Conference CD-ROM)

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