工業 4.0 之虛實系統（Cyber-Physical Systems Design）

Prerequisite: Graduate or Advanced student in Engineering.

Instructor: Shimon Y. Nof, Professor, Ph.D., D.H.C.

Class Time: 7/1/2016~7/27/2016

Tue, Wed, Fri 18:30-21:30; Sat 9:00-12:00

Place: IE Ⅱ 104, College of Engineering of Tunghai University, Taichung

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Course materials, handouts – Posted on class website

Textbook: *Revolutionizing Collaboration through e-Work, e-Business, and e-Service*, Nof, Ceroni, Jeong, Moghaddam, Springer 2015

http://link.springer.com/book/10.1007%2F978-3-662-45777-1

Course grade: HW-- 60%; project -- 40%

Course objectives – What we will learn:

- Cyber-Physical systems (CPS) have emerged for local, regional, and wide-area networks of both infrastructure and smart services and grids. They rely on (and cannot work well without) wireless communication, distributed automation and robotics, and collaborative control. I.E. researchers have identified collaborative e-Work (c-Work) as the foundation for CPS e-Services, e-Supply, and e-Business, and other electronic production/repair activities.
- As a new way of working in the digital economy, CPS enable e-Work with collaborative, cyber (computing- communication-and-control-) supported work in highly distributed and networked organizations of humans /robots /sensors/autonomous systems.
- Better CPS are designed with higher levels of CI (Collaborative Intelligence; see Table below, following Nof, Ch. 3, *Springer Handbook of Automation*, 2009.) This course is devoted to learning the basic principles, theories, models, and applications for the design of effective CPS, both locally and globally. Relevant and emerging discoveries at Purdue and elsewhere are also presented.

Level ↓	Automation	Automated Human Attribute	CPS Example
A_8	**Mobile machine**	**Guided mobility**	**Hovering motes; Connected vehicles/drones; Robot swarms**
A_9	**Collaborative network**	**Collaboration**	**CI-Hub; Smart grid; Collaborative telerobotics; Co-Insight; Shared service**
A_{10}	**Originality**	**Creativity**	**Virtual reality game; Innovation labs**

A_{11}	**Human and animal special needs Support**	**Compassion**	**Remote nursing device; Disaster rescue**
A_{12}	**Interactive companion**	**Humor; Patience**	**Advisory agents; Remote tutoring/training**

Topics included:

1.	**CPS, e-Work and e-Services fundamentals; The A+I (Analytics + Informatics) IE**
2.	**Design models; Industrial Internet/Cyber Physical Systems/Internet of Things (IoT)**
3.	**Workflow protocols; Agents; c-manufacturing and c-Service network paradigms and models**
4.	**Basic protocols for distributed CPS control; design of task administration protocols**
5.	**CPS case studies; Design criteria; performance metrics**
6.	**Design of CPS networks; Workflow models for service quality and its assurance**
7.	**CPS sensor networks and e-Services; TIE, Teamwork Integration Evaluation**
8.	**c-Work design and optimization; Evolutionary and bio-inspired design models**
9.	**CPS collaborative design; CLM; Networked interoperability**
10.	**Cyber-supported collaboration, CCT, and applications for CPS design**
11.	**Collaborative tele-machines and tele-robotics over CPS**
12.	**Emerging trends in theory and practice of CPS; project presentations**

Note for research literature (articles) review:

For homework and projects, students will include research analysis and summaries based on selected research articles. The structure includes (total limit of 2 pages):

(1) Problem addressed and its significance (general; and specific to the course scope);

(2) Background and known practice;

(3) New method(s), model(s), and results from this article;

(4) Strength and limitations of what is included in (3);

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(5) Critical evaluation: Specific impact on, and value for my understanding and further research.

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Professor of Industrial Engineering and also the director of the NSF-industry supported PRISM Center (Production, Robotics and Integration Software for Manufacturing & Management), Purdue University. Has held visiting positions at MIT, and universities in Chile, EU, Hong Kong, Israel, Japan, and Mexico. Received his B.Sc. and M.Sc. in Industrial Engineering & Management (Human-Machine Systems), Technion, Haifa, Israel; Ph.D. in Industrial & Operations Engineering (Production Analytics), University of Michigan, Ann Arbor.

Honors and Publications:

In 1999, Dr. Nof was honored among the inaugural group in Purdue's Book of Great Teachers. In 2002, he was awarded with the Engellerger Medal for Robotics Education. Fellow of IIE; Fellow, President and former Secretary General of IFPR; recent Chair of IFAC CC-Mfg. and Logistics systems . Dr. Nof has published over 400 articles on production engineering and information technology, and is the author/editor of twelve books, including the Handbook of Industrial Robotics (Wiley, 1985) and the

International Encyclopedia of Robotics (Wiley, 1988), both winners of the "Most Outstanding Book in Science and Engineering" award by the Association of American Publishers Industrial Assembly (Chapman & Hall, 1997, co-authored with H-J Warnecke and W. E. Wilhelm), the Handbook of Industrial Robotics (2nd Edition) (Wiley, 1999), and the Handbook of Automation (Springer, 2009).

Areas of scholarly and consulting work:

Collaborative e-Work and e-Business in multi-enterprise networks

Integrated production and service systems, and decision support

Design of systems for managing distributed activities by collaborative teams

His research pioneered the development of knowledge-based computer-aided facility design and control models. Current research focus is on computer-supported integration and collaboration of distributed e-Work and robotics, and CCT, Collaborative Control Theory.

Developed and has taught the courses:

Industrial Robotics and Flexible Assembly

Computer and Communication Methods in Production Control

Integrated Production Systems I and II

I.E. Computing

Design of e-Work and e-Service Systems