Ph.D. Projects (2003/2004)

IMST programme

Risk Management in Information-Driven Product Development

Student : Cai Yanling
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Thesis Advisor (MIT) : Dr Stanley Gershwin

Project Abstract :
At the early stage of product development, design alternatives are evaluated based on certain criteria, such as technical performance, multi-objective utility, satisfaction of customer requirements, demand and profitability, etc. However, such early estimations have a high tendency of being inaccurate due to vague knowledge on the alternatives, thus the selected "best" alternative could have a high probability of actually being inferior to the others, if more accurate information could be acquired. Therefore, the inaccuracy of such early estimation due to insufficient information should also be taken into consideration when making design selection. In this research, the selection of design alternatives is treated as in a statistical sense, rather than in a deterministic sense. Robustness of the selection decision and technical performance risk for each alternative are integrated with utility for reasonable decision-making. The manufacturing quality issues may be considered as an item of technical performance risk, borrowing from Variation Risk Management (VRM). Following that, optimal allocation of the total given development budget along the project progress will be investigated to maximizing the total risk reduction, suppose that the budget is only used to acquire certain amount of information at certain quality level. This research is going to develop a mathematical model for robust selection of design alternatives under uncertainty at the early stage by integrating potential risk and utility, and another model for optimal allocation of total budget to ensure the highest probability of development project success by maximizing the total risk reduction.

Design and Fabrication of Novel Chip for Proteins Separation and Identification

Student : Guo Xun
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(Singapore) : Prof Yoon Soon Fatt & Assoc Prof Chan Bee Eng, Mary
Thesis Advisor (MIT) : Prof Chun Jung-Hoon

Project Abstract :
As the development of biological and pharmaceutical industry, a fast and accurate method to separate and identify proteins in human body is necessary in varieties of areas, for instance, new drug researching, food analysis. Currently, a widely used technique to identify proteins is Mass Spectrometry; however, it is unable to give accurate results when different types of proteins are agglomerated together. In this project, a new technology will be developed based on capillary isoelectric focusing (CIEF) for proteins separation and MS for identification. A micro scale channel will be proposed and manufactured in the CIEF separation, using UV-Embossing which brings us advantages of low cost, high throughput and bio-compatibility. The structure and geometry will be designed based on simulation and experiments. After separation, proteins will be identified with mass spectrometry. Furthermore, some issues in the UV-Embossing will be discussed.

A Mobile Augmented Reality (AR) Fixture Verification System and Decision Making Model for the Shop Floor

Student : Jonathan Chong Wun Shiung
Thesis Advisor
(Singapore) : Prof Andrew Nee Yeh Ching
Thesis Advisor (MIT) : Prof Kamal Youcef-Toumi

Project Abstract :
Augmented Reality (AR) is a promising technology that has been used for various applications in the entertainment, medical, biomechanics, design and manufacturing sectors. AR is basically used to enhance a user's interaction with objects in the real world by superimposing virtual objects on the real world scene. Fundamentally, AR utilizes machine vision principles and can be divided into two major activities (1) Tracking and (2) Information display. The goal of this research is to develop a system that utilizes the benefits of AR in verification of the assembly welding fixture and decision-making tasks on the shop-floor. The principles of optical tracking will be used to perform measurements on the fixture. These measurements will then be used in analytical models to provide the necessary information needed by a decision-making model. The decision-making model, is aimed at providing useful insights on the functionability of the fixture and the necessary corrective actions (if any) to be taken. AR would then be used to present the outputs of the decision-making model and enable the user to perform on-site fixture maintenance. It is predicted that significant cost savings can be achieved with the proposed system.

Manipulation of Particles by using Electrokinetics and Dielectrophoresis

Student : Kua Chin Hock
Thesis Advisors
(Singapore) : Prof Lam Yee Cheong & Prof Charles Yang Chun
Thesis Advisor (MIT) : Prof Kamal Youcef-Toumi

Project Abstract :
During the last decade, large and costly instruments are being replaced by microfluidic devices based systems (also known as BioMEMS). Microfluidic devices hold the promise of combining a small analytical laboratory onto a chip-sized substrate to

identify, immobilize, separate, and purify cells, biomolecules, toxins, and other chemical and biological materials. Compared to conventional instruments, microfluidic devices would perform these tasks with faster speed, higher sensitivity and efficiency, and greater affordability, and they might also be used in the future for detecting chemical and biological warfare agents, delivering precise amounts of prescription drugs, and monitoring air and water quality. Microfluidic devices are fashioned from silicon, glass, plastics, and ceramics into 2- or 3- square-centimeter slices with cover plates. In them, red blood cells, bacteria, biological macromolecules (such as proteins and DNA), polystyrene beads (that bond to targeted macromolecules), and other materials can be manipulated in channels with characteristic length scales on the order of 100 micrometers. Thus, an understanding of particles motion in a network of microchannels is crucial to the optimal design and process control of microfluidic devices. In the proposed research, the motion of particles is controlled by using both electrokinetics and dielectrophoresis simultaneously. In particular, the liquid flow is driven by the electroosmosis based pumping mechanism. Compared to pressure-driven flow, the electroosmosis flow offers advantages including ease of fabrication and control, no need for moving parts and hence no noise, and high reliability. More importantly, for the flow actuated by electrokinetic pumping, its velocity profile is essentially flat across the channel. This type of flow is ideal for separations based on the charge-to-size ratio of the biological samples in solution, since broadening of the separated bands of differing species occurs only by diffusion, not as a result of the differences in flow velocity across the channel like the case of the pressure-driven flow. Dielectrophoresis refers to an interaction between the polarized particles suspended in conducting media and the non-uniform (either spatial distributed or frequency-dependant) electric field. The force resultant from dielectrophoresis can be quite effective in manipulating and positioning particles with electrodes using just several volts of electric voltage along the transverse direction of microchannels. Experimental studies of particle motion in microchannels will be carried out. Because of microscale channel and particle sizes, a confocal microscopy, which is available in the Material Lab of MPE, will be used to observe the behaviour of particles under the influences of electroosmotic flow, electrophoresis, and dielectrophoresis. Variation of particle electrokinetics and dielectrophoresis can be realized by changing the axial DC electric field strength, the channel geometric structure and configuration, the frequency, magnitude and arrangement of lateral AC electric field, and the buffer solution properties. The electrostatic and hydrophobic-hydrophilic interactions between particles and the channel wall can be manipulated by using appropriate chemical and polymer coatings.

Assembly Evaluation in AR environment

Student : Pang Yan
Thesis Advisor (Singapore) : Prof Andrew Nee Yeh Ching
Thesis Advisor (MIT) : Prof Kamal Youcef-Toumi

Project Abstract :
The technologies and methodologies of assembly design and evaluation in the early design stage are highly significant to product development. This paper looks at a promising technology to mix real components (e.g. physical prototypes, assembly tools, machines, etc.) with virtual components to create an Augmented Reality (AR) interface for assembly process evaluation. The goal of this research work is to clarify the methodologies and enabling technologies of how to establish an AR assembly simulation and evaluation environment. The architecture of an AR assembly system is proposed and the important functional modules including AR environment set-up, design for assembly (DFA) analysis and AR assembly sequence planning in an AR environment are discussed in detail.

Augmented Reality (AR) Assisted Design and Maintenance of Mechanical Systems

Student : Poh Yang Liang
Thesis Advisor (Singapore) : Prof Andrew Nee Yeh Ching
Thesis Advisor (MIT) : Prof Kamal Youcef-Toumi

Project Abstract :
Augmented Reality (AR) is a newly emerging technology which is not only capable of creating an enhanced environment by supplementing the real environment with virtual objects, but also extracting constraints from the real world. This project will focus on the latter to assist machine design using mixed prototyping. Using AR technology, real world geometric information will be used to guide the design process for 3D model creations and modifications, and selection of standard components. Analysis is conducted using deterioration models to provide a better insight on how a design will behave in due time. Modifications can be done to reduce machine down-time in the future through making the maintenance tasks more accessible and thus efficient. Besides, the system can also serve learning objectives by preserving best practices in machine design.

Lateral Transshipment Issue in Supply Chain Management

Student : Wang Yexin
Thesis Advisor (Singapore) : Assoc Prof Rohit Bhatnagar
Thesis Advisor (MIT) : Prof Stephen Graves

Project Abstract :
The typical one-warehouse and N-retailers distribution structure is widely used to distribute goods over a large geographical region. Each retailer places regular replenishment order from the center warehouse to satisfy the demand from local market. Besides the regular replenishment from center warehouse, a

retailer can also receive goods from another parallel retailer. Such kind of transshipment between parallel locations is called lateral transshipment, which provides new opportunities to better manage inventory. As a result, lateral transshipment can lead to system cost saving and improved service level without the need to increase stock. Our purpose is to develop a suitable lateral transshipment policy, which concerns the pipeline inventory and corresponding arriving time. The new information technology makes it easy to track the pipeline inventory in the system. An approximate system state description method is suggested to support the new lateral transshipment policy

Design of Manufacturing Systems with Quality Issues - Control Quality Point Policy

Student	:	Yang Rongling
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Thesis Advisor (MIT)	:	Dr Stanley Gershwin

Project Abstract :
The literature research reports on production system design and quality control separately. Production systems are designed with the assumption that all the products generated from the system are perfect. Quality control emphasizes on optimizing inspection parameters and inspection allocation without considering the issues related to the design of a production system such as job release, scheduling and other control policies. There is a lack of research in treating production system design and quality control simultaneously. The goal of the research is to begin to develop a model to improve system yield and reduce waste by taking into consideration of both quality and productivity.

Optimization of Micro-Patterning Processes

Student	:	Yeo Lip Pin
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Thesis Advisor (MIT)	:	Prof David E. Hardt

Project Abstract :
UV embossing for polymeric micro-patterning is an emerging replication technique with many unique qualities that satisfy the requirements for a simple setup, low cost fabrication with fast cycle time production. In order to further enhance this duplication method for higher aspect ratios production (>15), demolding must be hassle free. Thus, the motivation of this research project is to look into the material characteristics of multifunctional acrylates to achieve successful demolding. It is well known that as crosslinking density grows, the rigidity of the network formed also increases, which results in higher polymer strength. However, higher elastic modulus comes with a price of increased brittleness. The stresses evolved during and after the cure process are important. The polymer strength and polymer-mold surface strength have a direct impact on the ease or difficulty of demolding. As such, it is important to understand the tradeoffs for selecting one parameter over the other. The optimal conditions, by considering the above factors, will be chosen to accomplish a polymer micro pattern with good dimensional replication and high strength at the same time. Optimization will be carried out using numerical simulation with Cohesive Zone Modeling (CZM) to model the demolding process. Rate independent CZM laws are used to model dissimilar materials brittle fracture of polymer to mold interface. Seven milestones for the development of the models are proposed with the final model including factors such as changes in elastic modulus and viscosity as a function of cure, effect of volume shrinkage lag, transmissibility of light and diffusion effects. With this phenomenological approach in mind, the characterization of UV embossing process as materials cure (and post cure) will be examined.