ENGINEERING SYSTEMS AND DESIGN

NEWSLETTER

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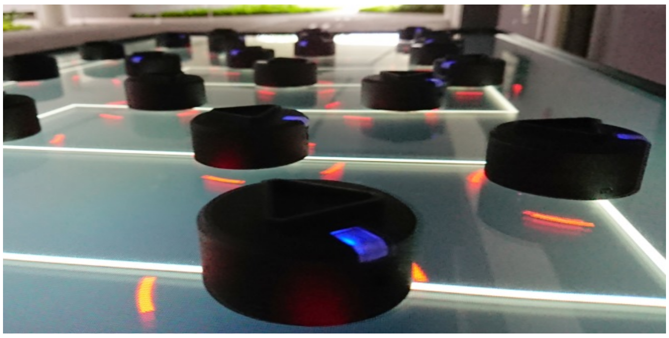
INSIDE THIS ISSUE

Introducing the Thumbles System

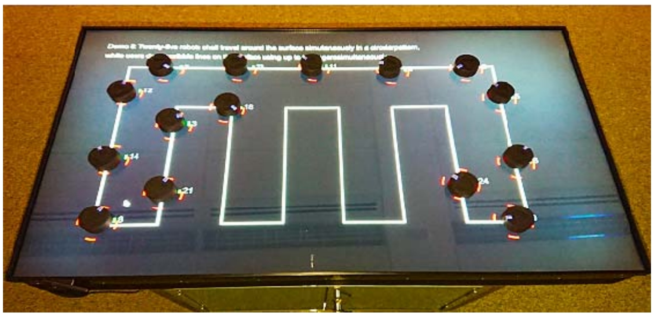
By Peter L. Jackson, Professor and Head of Pillar, ESD

Much of what we work with in ESD is intangible: system design, organisation, scheduling, decision-making, and analysis. There are great ways to visualize these concepts using graphics and computer animations but the intangible nature persists. What in ESD can we actually touch and feel? This question was the genesis for the Thumbles System, a collection of computer-controlled robotic pucks on a computer display surface, custom-designed for SUTD by Patten Studios in New York (James Patten is an innovator originally from the MIT Media Lab). Each puck, called a 'Thumble', can be directed to travel to any point on the computer surface and to rotate its orientation. You can attach platforms to the Thumbles to carry things as well. But you can also pick up the Thumbles and (gently) slide them across the surface. The computer tracks their location so you can use the Thumbles as input devices (like mice) and as output devices (like robots). We have also established Bluetooth communication with the Thumbles so you can use your smartphone to control their movements.

So what can we do with Thumbles? We plan to use the Thumbles System to teach agent-based modelling in our Simulation Modelling and Analysis course (Term 6). We hope to introduce Thumbles modules into other courses as well. I will also be running UROP projects for students to develop creative applications of this technology. So, if you are interested in creating games, or traffic simulations, or interactive optimisation tools using the Thumbles, sign up for a UROP experience: ESD made tangible!



Thumbles moving across a computer surface



Thumbles moving in a prescribed pattern

Thumbles in action during the Open House in March 2018

Meet Your Term 4 Professors

Bikramjit Das

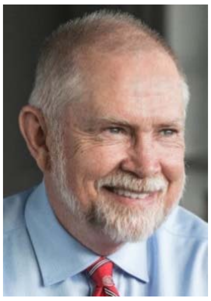
40.001 Probability

"Have you ever wondered about the chances of you scoring a goal, winning a lottery, or finding a mistake in your professor's notes? How about the chances of getting a Grab ride in the next three minutes, or why the normal distribution is so "normal"? We learn about the science of modelling uncertainty in the class."

40.002 Optimisation

"In this class we will learn the science and art of using mathematical tools to make decisions. The knowledge acquired can be applied to problems in various domains such as manufacturing, air traffic operations, resource allocation in hospitals, portfolio management in finance, humanitarian logistics, and policy making for sustainable operations."

Selin Ahipasaoglu



Peter Jackson

Ying Xu

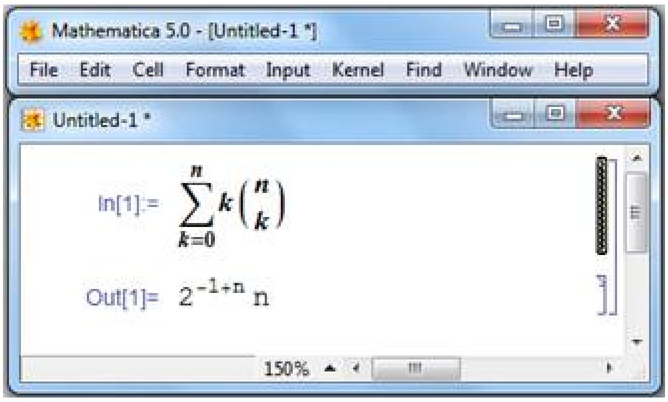
40.011 Data and Business Analytics

"In this course, you will be given an industrial project at the beginning of the semester and tasked to answer some question of interest to the project client. We will rapidly equip you with tools in data manipulation, data visualization, and data analytics that will enable you to answer the question. You will also pick up tools, such as process analysis, that will be valuable in future projects and internships."

Exciting Undergraduate Research Opportunities Programme (UROP) Projects in ESD

In ESD, you will have the opportunity to participate in exciting UROP projects that will give you a real-life research experience. Working together with ESD faculty, you will rigorously explore, investigate and validate hypothesis and glean useful insights. Through UROP, you will also get the chance to work on cutting edge research projects and participate in the different phases of standard research activity (i.e. developing research plans, writing proposals, conducting research, analysing data and presenting research results in oral and written form). Here are some of the on-going UROP projects that students are undertaking in ESD.

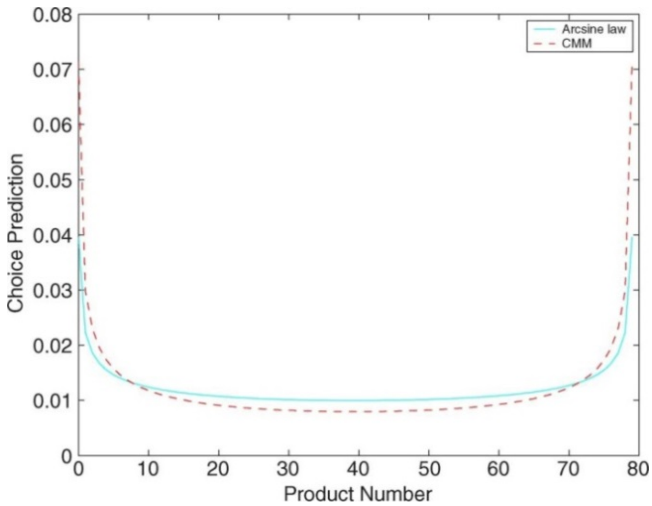
Computer Algebra (James Wan) – Computer algebra systems such as Mathematica and Maple are able to evaluate, prove and even produce combinatorial identities (see screenshot below):



Combinatorial identities in Mathematica

They can do so due to the methods of creative telescoping, the backbone of which depends on linear algebra. Celine's Method is the forerunner of all creative telescoping methods. This project aims to understand Celine's Method better, simplify its proof, and (if possible) make it more efficient. Students will be exposed to some special functions, some number theory, and will learn to implement generalizations of Celine's Method in Mathematica.

Closed Form Solutions for Random Walks (Karthik Natarajan) – In this project, the student explored the problem of finding the probability that in a correlated random walk, the maximum is reached at a particular step. While the classical approach assumes independent increments, in this work, random walks were studied by dropping the assumption of independence and instead using a cross moment model (CMM). Surprisingly, the model provides estimates that are close to the arcsine law which is a well-known characterization under independence (see figure below). In this project, we also developed closed form solutions for this problem for steps of size n = 2, 3 and 4. These models have applications in domains such as appointment scheduling in healthcare to capacity planning in reservoirs to choice modelling with products. This is joint work with Koh Jing Yu and James Wan.



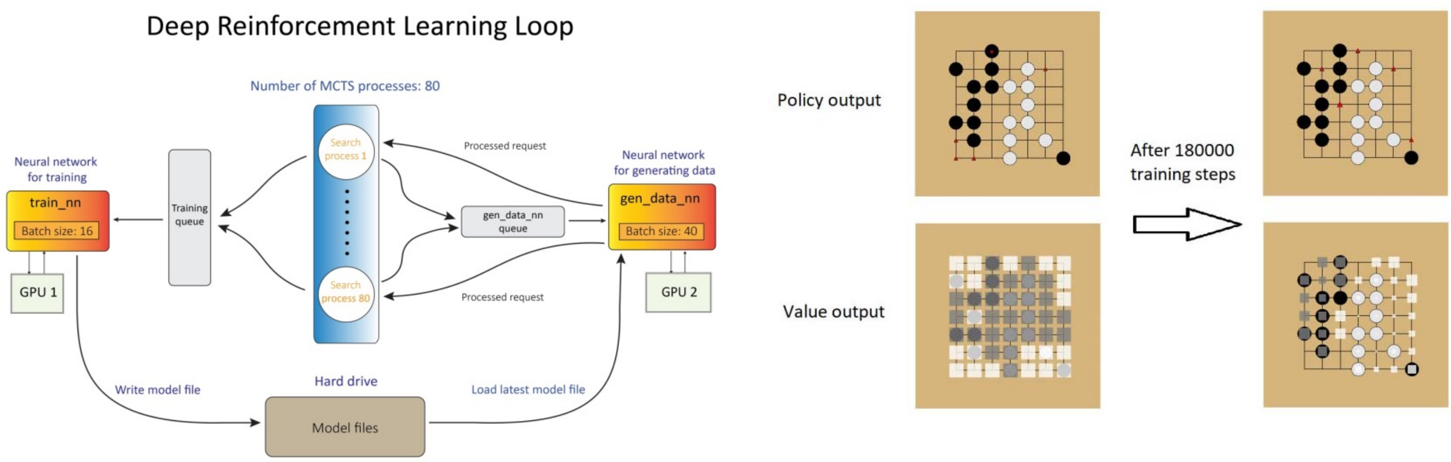
The Cross Moment Model gives estimates close to the arcsine law

Deep Reinforcement Learning in Computer Go (Nengli Lim) – In this project, we train a program from scratch to play Go using deep reinforcement learning. The program uses deep convolutional neural networks to output its best estimate of where to play next (policy evaluation), and its best guess on how good the current position is for either player (value estimation). It improves this estimation via self-play using Monte-Carlo tree search (MCTS), and no human supervision or prior knowledge is provided at any stage. Training and testing of the program, for various board sizes, is performed on SUTD's DGX-1 supercomputer. See figures on Page 4.

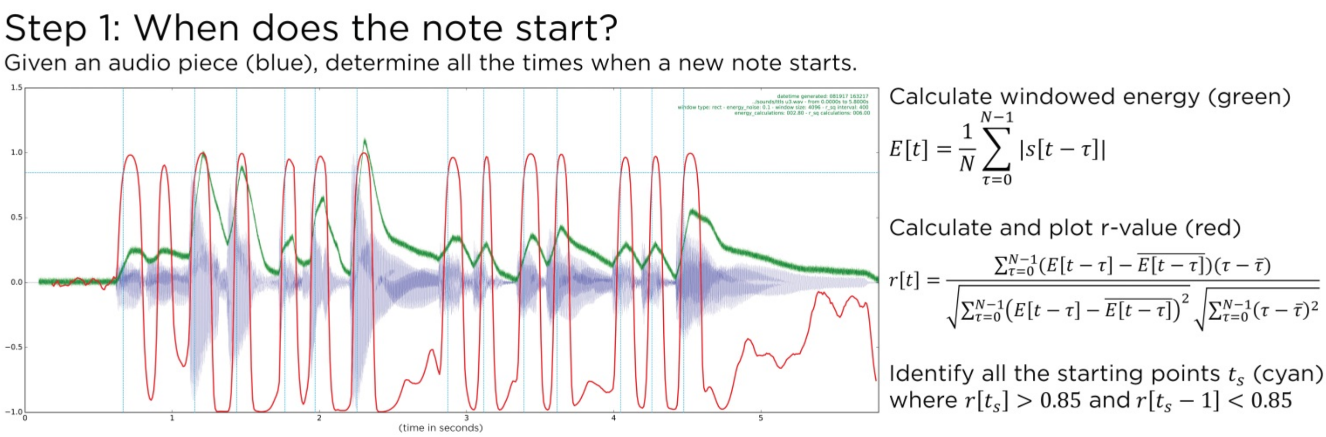
Music and Gaussian Models (Sergey Kushnarev) – Mathematically, music is a continuous random signal with a certain pattern. In this project, students will learn how to build a probabilistic model of a music piece. The scope of the project is to understand mathematics behind randomness in music (students must know probability, conditional probability, discrete and continuous Fourier transform, or at least be willing to learn it), and write code to characterize randomness of a musical piece.

Potential extensions of this approach include recovering the score from the music recording, synthesizing your own random music piece, and speech recognition.

Stochastic Gradient Descent (Sergey Kushnarev) – This UROP introduces student to the technique of stochastic gradient descent that is used in large scale optimization problems. Students will learn and implement the technique on a few examples, and then ultimately apply it to a project.



Deep reinforcement learning in computer Go



Music and Gaussian Models: Plot of an audio signal (in blue) and its windowed energy (in green). One of the ways to determine when the note starts is to determine when the correlation coefficient r (in red) exceeds a certain threshold.

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