



School of Computing

2013

# Why Study Computing at the NUS School of Computing?

Creating  
Your  
Future



Knowledge that Makes an Impact

Learning that Makes a Difference

with Computing



Education for Impact and  
Change

# Why Computing?

## A Bit of History

In 1936, Alan Turing asked the question of what a human can compute. To answer the question, he invented the Turing machine, the simplest computer. To this day, anything that humans know how to automate, can be automated using the computer.



## Rapid Growth and Rapid Change

In 1965, Intel co-founder, Gordon Moore, predicted that computer performance would double every year. The prediction has held true (performance doubling at roughly 18 months), and the exponential growth is

expected to continue for the near future.

### Highlights

- Computing resources has been doubling every eighteen months and will continue to do so in the near future.
- This results in a tremendous amount of opportunities as well as rapid changes.
- The rapid changes affect not just the computing industry but all professions. Some jobs are automated away, and most jobs will be augmented by computers.
- Education in computing allows you to exploit the opportunities provided by the rapid changes.
- Education in computing allows you to understand automation and change from a scientific, engineering, or business points of views. Consequently, it allows you to adapt quickly when technology changes. At the same time, your knowledge opens up a wide range of career opportunities outside of computing.
- Successful people with degrees in computing range from the CEO of Singapore Airlines to the Prime Minister of Singapore.

To understand this rapid growth, it is useful to recall the story of the invention of chess.

According to an old fable, chess was invented by an Indian mathematician. When the king saw the game, he was very pleased and asked the mathematician what he would like as a reward. The mathematician asked for one grain of rice for the first chess square, two grains for the second square, doubling the amount for each square until the 64<sup>th</sup> square. The king quickly agreed to the request, not realizing the amount of rice being asked. After ten squares, the amount requested is only approximately a thousand grains, but after 64 squares, the heap of rice would be larger than Mount Everest!<sup>1</sup>

So where are we on this exponential curve? We are now able to build computing machines with a similar amount of computing power as that of the human brain. And each year and a half, the amount of new computing power available in the world is roughly the same as all the computing power of all the computers that have ever been built. IBM's Deep Blue defeated the world chess champion, Gary Kasparov in 1997. Recently, Google car drove

<sup>1</sup> [http://en.wikipedia.org/wiki/Wheat\\_and\\_chessboard\\_problem](http://en.wikipedia.org/wiki/Wheat_and_chessboard_problem)

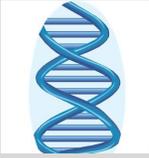
without human intervention in city roads for thousands of kilometers, and IBM's Watson defeated the world best humans in a natural language quiz game, Jeopardy, in 2011.

What are the implications of the exponential growth? It provides tremendous opportunities. With the doubling of resources every eighteen months, many things that were not previously possible suddenly becomes possible. Singapore has limited manpower but can easily double its amount of computing resources every eighteen months – automation has to be one of the main avenues of productivity growth. The best chess players are now computers. Will the best doctors and the best lawyers also be computers soon? Looking at the current trend, it is unclear if this will happen soon, but almost certainly, a doctor or lawyer assisted by a computer will be better than one who does not exploit the technology.

Exponential growth in computing resources results in unpredictable change in all professions. According to MIT economists Erik Brynjolfsson and Andrew McAfee, corporate profit rebounds quickly after recessions but employment recovers slowly as jobs that can be replaced by technology during corporate tightening caused by the recessions are no longer available. Over time, society adapts, and new opportunities are created, but those affected have their lives disrupted.

So, which jobs are likely to be affected, and when? The eventual outcomes are sometimes predictable, but the timing is very difficult to foresee as doubling of resources can cause discontinuous changes. The World Wide Web was foreseen back in 1945 by Vannevar Bush, but it did not become pervasive until the end of last century. Computers are finally able to beat the best human chess player, but this took longer than many experts expected. Experts predicted that machine translation would be a

## How Computing is Changing the World

- Computing is currently changing the way higher education is done through freely available Massive Open Online Courses (MOOC). Have a look at the many Singaporeans actively involved in making this possible at 
- The whole human genome has been sequenced, allowing computerized analysis. Science is increasingly being done on the computer. 
- Computing has changed the way we search for information, allowing instant access through search engines and real time updates of information. 
- Computing has changed the way we communicate with email replacing regular mails and audio and video conferencing increasingly reducing face-to-face meetings.  Social networks have changed the way we socialize.
- Almost all of business, from customer service, operations, decision making, human resources and marketing is done with the help of computers.
- Algorithmic trading is becoming more common. Finance is increasingly being computerized.
- Shopping is increasing being done on the  computer.
- Many devices such as automobiles, fridges, televisions, and phones now have computers embedded in them.
- What else? The limit is your knowledge and your imagination ...

solved problem in the 1950s, but it is still unsolved, although rapid progress has been made recently. On the other hand, not many people would have expected self-driving cars in city roads so soon!

Despite the unpredictability in the timing of technology success, the available computing resources have been dramatically and reliably increasing. Information technology has become ubiquitous and pervasive in all organizations and society as a whole. This resulted a large demand for computing professionals. In the 2011 graduate employment survey, information systems graduates in NUS have the highest gross salary after doctors and lawyers, while in the 2012 survey, computer science graduates in NUS have the highest gross salary after doctors, dentists, architects and business graduates who completed an extra honours year. The statistics from code.org on the situation in the US (shown on the right), gives a vivid illustration of this. Go to code.org and check out the video there as well.

### What can I do?

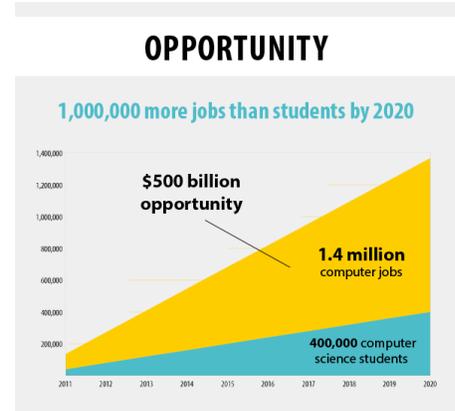
No matter what you decide to do, you should be prepared for the potentially disruptive effects of technology.

One option you should consider is education in the computing area. The increasing amount of available computing resources means abundant opportunities for those who want to make a difference and change the way things are done. Computing education prepares you to be

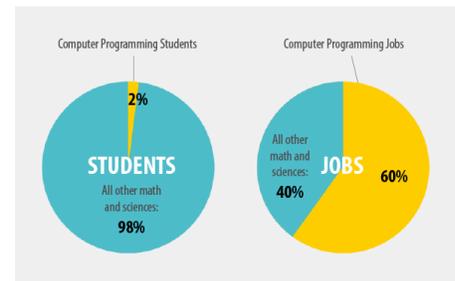
- Scientists, who try to understand and push the boundaries of what can be done by the rapidly increasing amount of available computation.
- Engineers, who build systems that change how people live.
- Data and business analysts who exploit the large amount of available data to obtain useful insights that can provide competitive advantage for their organizations.
- Managers who are able to exploit technology to improve productivity of their organizations.

Scientists  
 Engineers  
 Leaders  
 Entrepreneurs  
 Analysts  
 Managers

What's wrong with this picture?



COMPUTER SCIENCE IS THE **HIGHEST PAID COLLEGE DEGREE** AND **COMPUTER PROGRAMMING JOBS ARE GROWING AT 2X THE NATIONAL AVERAGE.**

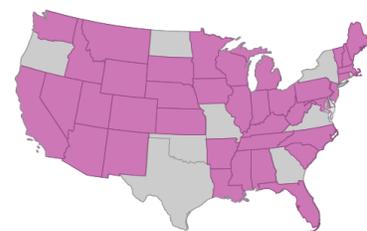


LESS THAN 2.4% OF COLLEGE STUDENTS GRADUATE WITH A DEGREE IN COMPUTER SCIENCE... THAT'S FEWER THAN 10 YEARS AGO.

9 out of 10 schools don't even offer computer programming classes



IN 41 OF 50 STATES, CODING CLASSES DON'T COUNT TOWARDS HIGH SCHOOL GRADUATION MATH OR SCIENCE REQUIREMENTS.



Learn to code, visit [code.org](http://code.org)

- Entrepreneurs who start new ventures to bring changes to society.
- Leaders who understand how technology affects society and can be used to improve the lives of people.

In the computing area, your understanding of science, mathematics, and business can be immediately applied and is in high demand in industry. The demand for talented people in the technology area is high not only in Singapore but also globally. Technology companies such as Facebook, Google, and Microsoft have been recruiting fresh graduates in Singapore universities for jobs (with six figure annual salaries) worldwide to address the global shortage of talent. If you are good at what you do, you can easily get a job working with the best in the world, anywhere in the world.

What if you are not sure if the computing industry is suitable for you? It is true that education in the computing area is challenging, with difficult but useful concepts to master and long hours of hard work. However, this is true of all worthwhile areas of study. The result of the hard work is that you understand automation, from a scientific and engineering point of view or from a business point of view. The rapid changing nature of the industry also means that you are exposed methods for handling changes as part of your education and are able to adapt and learn independently. Combined with general education from the university, you are well prepared to enter and thrive almost anywhere. Computing education prepares you well for a career in the sciences, engineering, or business and for careers in most areas requiring a general university education. It also serves as excellent background to rise to the highest level of any profession. For example, NUS Computing alumni, Ms Tan Yen Yen, was Managing Director at HP Singapore and is currently Senior Vice President at Oracle Corporation. The CEO of Singapore Airlines, Mr Goh Choon Phong, has a Bachelors and Masters degree in Computer Science and Electrical Engineering from MIT. The Prime Minister of Singapore, Mr Lee Hsien Loong, has a Diploma (equivalent to Masters) in Computer Science from Cambridge. The Deputy Prime Minister of Singapore, Mr Teo Chee Hean, has a Masters in Computing Science from Imperial College. So, if you are not sure, don't worry, a computing education is an excellent choice for education that gives you a wide array of options when you graduate.

## To Find Out More

- Read Nobel Prize Winner in Economics, Paul Krugman's article in the New York Times *Degrees and Dollars* <http://www.nytimes.com/2011/03/07/opinion/07krugman.html>
- Read MIT economists Erik Brynjolfsson and Andrew McAfee's book *Race Against the Machine* <http://raceagainstthemachine.com/>
- Read the Wall Street Journal article *The Average Silicon Valley Tech Salary Passes \$100,000* <http://cacm.acm.org/careers/145929-average-silicon-valley-tech-salary-passes-100000/fulltext>
- The Graduate Employment Survey is available at <http://www.moe.gov.sg/education/post-secondary/>

## Why NUS School of Computing?

We are ranked best in Asia and 9<sup>th</sup> in the world by QS World University Rankings. Our faculty members rank among the world's best researchers, winning many best paper awards in the best conferences and journals.



Rahul Jain  
Best Paper  
STOC 2010



Yu Haifeng  
Best Paper  
SIGCOMM 2010



Pan Shan Ling  
Best Paper  
IEEE Trans.  
Eng. Management  
2010



Chua Tat Seng  
Best Paper  
ACM MM 2010



Ben Leong  
2009 ComSoc and  
Info Thy Society  
Joint Paper Award



Atreyi Kankanhalli  
Best Paper  
PACIS 2010



Ling Tok Wang  
DASFAA 10 Year  
Most Influential  
Paper 2011



David Rosenblum  
SIGSOFT Impact  
Paper Award 2008

We have excellent teachers. For example, we have six faculty members on the NUS Teaching Honour Roll (three-time winners of NUS Annual Teaching Excellence Award).

Our graduates are in high demand, with close to a hundred percent employment. Outside of law and medicine, information systems had the highest average gross salary of NUS graduates in the Graduate Employment Survey 2011, while Computer Science and Computer Engineering had among the highest average gross salaries in 2012. Many of our graduates have also joined global companies such as Facebook, Google, and Microsoft in the US at six-figure starting salaries in recent years. Our graduates are not only in high demand but also global.

### Educational Philosophy

The School of Computing strives to educate students to become

- Individuals with questioning minds who are able to engage in rigorous enquiry within and beyond disciplinary boundaries in a manner consistent with the NUS educational philosophy.

### Highlights

- NUS School of Computing is ranked best in Asia and 9<sup>th</sup> in the world by QS World University Ranking.
- Our faculty members excel in research and teaching.
- Our graduates are in high demand in industry, both locally and internationally.
- We educate our students in the fundamentals, allowing our students to adapt quickly to disruptive changes that are often caused by technology.
- There is large demand for computing manpower in the industry, but our students' good understanding of technology and change gives them great flexibility in career choice, even outside of technology and business domains.
- We offer a wide range of differentiated personalized programs to suit your preferences and needs.
- SoC students are passionate about exploiting technology for the benefit of society
- The school offers six degrees in computer science, computational biology, computer engineering, information systems, business analytics and e-commerce.

- Individuals who understand the fundamentals of computing in general, and computer science or information systems in particular.
- Individuals who understand the rapid changes driven by technology and automation and who are able to exploit the changes for the benefit of society.

SoC students have strong broad-based education, allowing them to adapt easily to jobs that require university-educated generalists. In addition, students in the Department of Computer Science have strong background in science and mathematics, allowing them to independently learn new topics in these areas quickly. Students in the Department of Information Systems have strong background in accounting, economics and management, allowing them to adapt quickly across different businesses. Courses in SoC emphasize the fundamentals that do not change quickly. With a strong foundation, SoC graduates are able to adapt quickly to new changing technologies. Within their courses, students will use many technologies, will learn how new technologies relate to the fundamentals, and will get a sense of how future technologies will evolve from current technologies. Students also learn methods for dealing with changes that are applicable beyond technology areas.

As far as possible, SoC education will future-proof the students in allowing them to adapt quickly to changes and to exploit opportunities created by changes in both technology and more general areas.

## Differentiated Personalized Program

We recognize that different students have different educational preferences and needs. There is a wide array of programs available to SoC students to suit your needs.

- **University Scholars Program.** For those who prefer a broader education than that provided by the regular NUS curriculum, USP is a selective interdisciplinary program well known for producing highly capable well-rounded students.
- **Double and Concurrent Degree and Programs.** For those who prefer to get two degrees within 5 years, we allow self-designed double degrees as long as the self-designed degrees meet the approval of the two participating faculties. Popular pre-approved double degrees with accountancy, business administration and mathematics are also available. Similarly, we have



**Chris Henry**

Software Engineer at Google  
San Francisco Bay Area | Computer Software

*SoC alumni are in high demand globally with many working in top computing companies such as Google.*

### SoC Alumni Profile: Chris Henry

- B.Comp Computer Science 2009
- University Scholars Programme
- Undergraduate Research Opportunity Programme (Plenary speaker NUROP congress 2009)
- Undergraduate tutor CS1101S, CS1102S, CS3216
- Internship (Google)

concurrent degrees which combine a Bachelors and a Masters degrees and can be completed in 5 years.

- **Concurrent Overseas Degrees.**

We recognize that being immersed in a different culture allows you to grow and learn in many different ways. For students who would like to broaden their outlooks through obtaining an overseas degree, we offer SoC undergraduate degrees that are tightly coupled with Masters degrees at prestigious overseas institutions. We have programs with the best French engineering schools, the Grandes Ecoles, with Brown University, with Cambridge University, and with Carnegie Mellon University. Tight coupling with double counting of credit allows you to shorten the time required to complete the two degrees. Students in these programs obtain the breadth and cultural exposure that comes from a substantial overseas experience, get degrees from two top ranked institutions, and have two alumni networks with contacts in two countries to draw on.

And this can all be done in a duration that is shorter than obtaining the two degrees separately, and at a cost that is more likely to be affordable for those who do not wish to be bonded by an overseas scholarship.

- **NUS Overseas College.** Experience first-hand how entrepreneurs start new ventures to exploit the rapidly increasing technological resources by spending a year overseas working at a start-up while taking courses at prestigious partner universities Stanford, UPenn, Fudan, Tsinghua and the Royal Institute of Technology (KTH).
- **Research Based Program.** Discover the secrets of nature. Invent the future. These are the things researchers do. But research teaches you more than that. You learn how to ask questions, how to answer them and how to validate whether your hypothesis is correct. These are useful and highly adaptable skills to have in any profession. Besides being teachers, university professors are professional researchers – there is no better place to learn to do research. Become apprentice to professors and see how their research groups operate. Participate in the Undergraduate Research Opportunity Programme. The Turing Program in Computer Science is specially designed for students interested in a research-based education.



### Wei Yang Lim

Manager at International Enterprise Singapore, Precision Engineering Division  
Singapore | International Trade and Development

Current	Manager at International Enterprise Singapore
Previous	ST Electronics (Training & Simulations: Air), Ministry of Defence of Singapore
Education	M.Phil, Management at University of Cambridge

*A SoC concurrent overseas degree provides accelerated learning for top performing students and holistic education through cultural exposure. Concurrent degree students get degrees from two top ranked institutions in a shorter duration compared to doing the undergraduate and Masters degree separately (4 years to obtain a SoC information systems honours degree with a Cambridge management Masters)*

#### SoC Alumni Profile: Lim Wei Yang

- B.Comp Information Systems 2012
- M.Phil. Management, Cambridge 2012
- CaselT 2011 International Business Case Competition, 3<sup>rd</sup> place.

- Build and Innovate.** How do you build planetary wide systems such as the internet? How do you design secure computer systems for a bank? And do that while requirements are changing and the amount of available computation doubles every eighteen months. The von Neumann program in Computer Science is designed to help you focus on issues in building complex large scale systems. And what about cool systems? How do you come up with the next cool idea that is not only cool but also required by real users? How do you then differentiate your ideas? SoC has an innovation track for students interested in generating creative ideas, differentiating their ideas, and identifying business opportunities for their ideas. The innovation path is designed to fit well with the von Neumann program as technical competence is one key competitive advantage in starting new ventures to bring innovative ideas into realization.
- Leadership.** To lead, first you need to have the right ideas, then you need to convince people to work passionately towards those ideas, and finally, you need to monitor, manage, and ensure that the ideas are implemented effectively (c.f. Steve Jobs). SoC students have good understanding of technology, automation, and the disruptive changes that technology can bring – they have been well educated and are well positioned to have the right ideas. The SoC Leadership Program helps to get you the rest of the leadership skills.

*SoC education equips you with the fundamentals to go into many different areas. Your ability to adapt to changes will serve you well in your career. SoC alumni can work in the infocomm area or move easily into related specialized roles, such as trading, or generalist roles, such as management.*



**Winne Soh 苏晓琪**

Business Consultant, Social Innovation at Infocomm Development Authority of Singapore

Singapore | Information Technology and Services

**SoC Alumni Profile: Winne Soh**

- B.Comp Information Systems, Technopreneurship Minor, 2007
- SMU MBA Scholarship
- Co-Founder, Dream Axis Pte Ltd, 2008
- Singapore Computer Society IT Youth Award 2009



**Junfu Cai**

Trader

Singapore | Financial Services

**SoC Alumni Profile: Cai Junfu**

- B.Comp Computer Science 2007
- Masters, Computational Finance, CMU, 2008



**Mihir Sridhar**

Management Associate, HSBC Management Development Program, 2011

Singapore | Financial Services

**SoC Alumni Profile: Mihir Sridhar**

- B.Comp Computer Engineering, 2010
- Undergraduate Tutor, 2010
- NUS Overseas College, Silicon Valley, 2009



SoC students are well positioned to exploit the latest technology to become successful technopreneurs. While still a student at SoC, Travis Ho (pictured on left) co-founded the company Touch Dimensions to work on 'Autumn Dynasty', a real time strategy game for the iPad. With many of his classmates joining in to help with programming, 'Autumn Dynasty' was released on the Apple Appstore as a finished product, becoming the #1 iPad strategy game in 28 countries for several weeks. Based on his studies in artificial intelligence, computational geometry and human computer interaction, Travis developed a control scheme to allow players to command armies by simply drawing their plans on a battle map. This system of interpreting complex gestures eventually earned the game a feature in Apple's Benchmark Games pick for Intuitive Controls— a perfect example of how algorithms, art and creativity can come together at SoC to create compelling, real world products.



## Passionate Students as Peers

At SoC you will make lifelong friends with peers who are as passionate about exploiting technology for the benefit of society as you are.

SoC students have been volunteering their time helping the Singapore community by using their computing skills to build



computer systems for volunteer welfare organizations. The Computing Volunteer Welfare Organization (CVWO) <http://www.comp.nus.edu.sg/~vwo/home.html> was awarded the Friend of the Lions Befrienders Award, the highest distinction honour conferred on exemplary individuals or organisations for their contribution to the Lions Befrienders Programme in 2011.



Many SoC students spend their summer holidays on open source projects. In open source projects, many people around the world collaborate to build software that can be used and modified by anyone for free. Open source projects power much of the technical world and includes the Android operating system, the Apache server and many other commonly used software. By working on open source projects, SoC students learn an enormous amount and at the same time do good for the society. Furthermore, for students who are good enough to qualify for Google Summer of Code <http://code.google.com/soc/>, Google pays the student US\$5000 to do the open source work. NUS had 21 students qualify for Google Summer of Code in 2012, the second highest in the world!



A hacker is someone who enjoys creating interesting software (not to be confused with someone who exploits weaknesses in computer systems). The NUS Hackers <http://nushackers.org/> is a student organization dedicated to the spread of the hacker culture. They have weekly meetings with interesting talks (and usually pizzas!) and strong ties to the start-up community in Singapore.

The Association for Computing Machinery (ACM) is the main professional body representing computing professionals around the world. The NUS Student Chapter of the ACM <http://www.nusacm.org/> actively organizes the most interesting events, talks and workshops for the technologically inclined.



The Computing Club represents the undergraduate students in SoC. It provides support for students, enhance their welfare, organize activities and liaise with the school and the university on behalf of the students. Comp Club activities provide a wonderful opportunities to bond with fellow students, serve to your peers, and at the same time learn to organize and lead large scale events <http://nuscomputing.com/>.

## Who should do Computing at SoC?

Doing well in computing requires you to be able to think at several levels of abstractions, so being good at mathematics is an indication that you may be suited for computing.

In addition, if you have strong interest in business, then the information systems degrees may be appropriate for you. Our information systems degrees will give you an excellent combination of computing and business fundamentals that will allow you to bring technology into organizations and to adapt to any area of business.

If you have interest in science subjects, then computer science degrees may be appropriate. The computer science degrees give broad background in science and mathematics as well as more specialized knowledge in computing. Your broad scientific background and knowledge of the fundamentals of technology will give the versatility to work in many industries and the ability to adapt to changes in technology.

If you have interest in mathematics, science or business, and would like an education that allows you

- to exploit the exponential growth of technology to make a difference in the world, and
- have the fundamentals and versatility to adapt well to changes caused by technology

then you should consider an SoC education.

You should always make an informed decision, so we suggest that you try out some of the available online introductions to computing. We recommend going to <http://www.udacity.com/> and looking up their Introduction to Computer Science course, which requires no background but will cover enough for you to build a search engine (a simple Google!).

## Departments and Degrees

The School of Computing has two departments: the Department of Computer Science and the Department of Information Systems.

The **Department of Computer Science** offers three degrees.

- **Computer Science** covers the fundamentals of computing technology and offers 11 focus areas: Algorithm & Theory, Artificial Intelligence, Computer Networks, Database Systems, Information Retrieval, Interactive Media, Parallel Computing, Programming Languages, Software Engineering, Systems Security, and Visual Computing. Students in Computer Science obtain broad fundamentals in Science, Mathematics, and Computing, as well in-depth knowledge of their chosen focus areas.
- **Computational Biology** applies computing techniques to life sciences, enabling large knowledge bases in biological knowledge to be utilized to make advances.
- **Computer Engineering** is jointly offered by the Department of Computer Science and the Department of Electrical and Computer Engineering in the Faculty of Engineering. Computer engineering students study computing together with signals, sensors, systems, and embedded technologies allowing them to effectively apply computing in the physical world. The computer engineering degree is taught using the innovative CDIO (Conceive - Design – Implement - Operate) teaching methodology, which emphasizes fundamentals set in a real-world context.

The **Department of Information Systems** offers three degrees.

- **Information Systems** covers computing and business fundamentals, focusing on management of information technology within business and organizations.
- **Business analytics** is a multidisciplinary major that applies computing to large data in order to obtain useful business insights.
- **E-Commerce** combines computing and business knowledge to educate graduates competent in the area of e-business.

Details on what NUS School of Computing offers can be found at

<http://www.comp.nus.edu.sg/undergraduates/>.