

# The Ring

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# Puck.js



Gordon Williams started the Espruino project in 2012. Puck.js is the third successful Espruino Kickstarter and, since Christmas, over 20,000 devices have been shipped worldwide.

First it was Espruino, the first Java Script microcontroller. Then came Espruino Pico which allows you to control electronics quickly and easily with a tiny USB stick that runs JavaScript. Gordon Williams's latest Kickstarter project is Puck.js, an open source JavaScript microcontroller that you can program wirelessly.

*TR: Can you explain what Bluetooth LE is, and why it's interesting?*

GW: Bluetooth LE (Bluetooth Low Energy or Bluetooth Smart) is a 2.4Ghz radio standard originally created by Nokia. Unlike normal Bluetooth it's designed for low power and cost rather than high bandwidth.

Bluetooth LE radios are now in almost every new phone, tablet and PC. This sets it apart from other low power radio standards as you don't need a separate 'hub' (you can just use your phone or PC to communicate directly).

*Puck.js can be any kind of Bluetooth LE device (light, keyboard, heart rate monitor, etc), and can also control other devices. The interpreter also allows you to program and debug it wirelessly.*

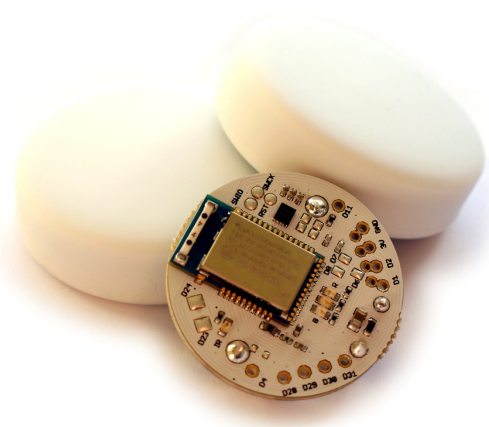
*TR: What is a Bluetooth Beacon?*

GW: Bluetooth Beacons are small self-contained devices that repeatedly broadcast a short BLE message around once a second. Beacons like Apple's iBeacon and Google's Eddystone transmit data in a fixed structure that once verified can direct you to a website. When you get near a beacon, your phone will display a (passive) notification.

However there are many other uses for beacons such as coarse positioning (of a user relative to beacons, or of beacons relative to receivers). Their low price (sometimes less than \$5 each, including case and battery), makes them extremely attractive.

*TR: Puck.js is a Bluetooth low energy (BLE) beacon. What is special about it?*

GW: Puck.js can be a BLE beacon, but it's a lot more than that. It contains a button, temperature and light sensors, a magnetometer, IR transmitter, and a full Bluetooth LE implementation (both a master and slave) along with the Espruino JavaScript interpreter (software I've been developing for the past few years). Puck.js can be any kind of Bluetooth LE device (light, keyboard, heart rate monitor, etc), and can also control other devices. The interpreter also allows you to program and debug it wirelessly.



*Puck.js*

TR: So why is that useful? Surely all embedded software should just be written in C/C++?

GW: Unfortunately it's not quite that simple. Most BLE-capable microcontrollers implement the majority of the bluetooth stack in software on the main processor. This means that even though you can in theory connect a debugger, if you actually break execution then whatever bluetooth connection you had will disappear. The bluetooth stack also enables a watchdog timer, so even if you don't have a bluetooth connection it's still very frustrating to debug.

The bluetooth implementation is also heavily interrupt based, so if you're not very careful it's easy to introduce subtle bugs into your software. There are also occasional hardware bugs in the microcontroller itself that need working around. The process is unfriendly for any developer, and is especially confusing if you've never dealt with embedded devices before. The Espruino JavaScript interpreter in Puck.js hides much of that complexity, and makes it easy for anyone to create a wireless embedded device.

There's also been a recent push by Google to add Bluetooth Low Energy APIs into web browsers (Web Bluetooth), so it's finally possible to write platform-independent code that interfaces with hardware. This means that with Puck.js you can use the same language (JavaScript) at all levels of your system: on the client in the web browser, on the server using Node.js, and on the embedded device with Puck.js.

*So far I've chosen to run my company without external investment, so everything was designed and assembled at home.*

TR: You used Seeed Studio in China to manufacture the components for Espruino. Why did you go overseas?

GW: For my first Kickstarter (a development board that runs JavaScript) I used Seeed because they provided a neat package called the OPL. You could buy a big kit of parts from them, all of which came with pre-made part outlines for PCB CAD software. By itself that was amazingly helpful and if you then made a prototype Seeed would manufacture it for you using their parts which were cheap and always in stock. It was a great service, which Seeed are planning to reintroduce soon.

For my second Kickstarter I had a much more compact design that couldn't use many of the parts from Seeed's OPL, so I thought I'd use a British manufacturer that had been recommended to me.

Unfortunately this didn't work as well as Seeed for me.

In the end, 15% of the boards were destroyed during the final step of production, another 25% were sent to the wrong address, and, just to rub it in, the very last panel of boards was sent to me with every microcontroller soldered on backwards. When it came to customer service, it became obvious that I came right at the back of the queue, behind people with much more valuable orders.

So I'm now manufacturing overseas again, because, in my (limited) experience, the manufacturers have been more competent, cheaper (but not by as much as you'd expect), and treat me like a valued customer.

*I feel like crowdfunding has really has opened the door for anyone with a bright idea, a bit of time and the desire to get stuck in.*

TR: Can you tell me about the design and manufacture of Puck.js?

GW: Puck.js is more mass-market than my previous developer-focused boards. I wanted to make something in an attractive case that was easy to use and less intimidating than a bare board.

So far I've chosen to run my company without external investment, so everything was designed and assembled at home. I designed the PCBs and case with free software, sent them away to be manufactured and assembled the prototypes myself.

While low end 3D printers are becoming increasingly affordable, when making Puck.js I discovered how easy and cheap it is to send designs away for professional 3D printing. A prototype PCB cost £3 and a prototype 3D printed case cost £15 (including a 3D printed rubber cover). Both were ordered by uploading files to a website and arrived within 10 days. Assembling everything used about £100 worth of tools.

The video was shot on a normal mirrorless camera and compiled in iMovie, then uploaded to Kickstarter, where I managed to sell about £100,000's worth of devices. I've just received 6000 assembled devices made by workers I have never met in a country I've never been to, and it has all been done with minimal investment and very little risk.

I feel like crowdfunding has really has opened the door for anyone with a bright idea, a bit of time and the desire to get stuck in. There's no reason a student at Cambridge couldn't have done something similar from their student room (and I'm sure some probably have!).

*TR: Puck.js is your third successful Kickstarter project. What is your advice for Kickstarter success?*

GW: Personally, I'd say it's advertising. It's not enough just to put a project online and hope people will back it. It might have been a few years ago when the media kept checking KickStarter for projects, but now it requires some real effort. Kickstarter won't necessarily promote your project (as one of their "projects we love"), and even if they do that will still only bring in a limited number of backers. You'll need to contact all the blogs and online magazines you can think of before you launch: just one article in the right publication can make a massive difference. However once you're a week into your KickStarter you'll find it difficult to get publicity until the final few days when it becomes newsworthy again.

*TR: Is a fourth project in the pipeline?*

GW: I've already got a JavaScript + WiFi board that I designed but didn't KickStart, so I now have four products offering a range of features. I'm planning to focus on selling those existing products, and I'm also going to start producing weekly videos of Microcontroller projects — something which seems to be missing from YouTube at the moment. I'm also working on a book of Espruino-based projects, although it's been put on hold a bit over the last few months while I have been focussing on getting the Pucks shipped in time for Christmas!

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*More information about Puck.js — including details on how to order — can be found at <http://www.puck-js.com/>*

# RealVNC and Raspberry Pi

## Sharing a passion for nurturing the computer skills of young people.

RealVNC, the original inventors of VNC remote access technology, and the Raspberry Pi Foundation, the UK-registered charity responsible for the low-cost Raspberry Pi educational computer, share more than just a core set of values. This pair of successful Cambridge-based organisations also share the same starting point: Cambridge University's Computer Laboratory.

Several RealVNC founder members, including Andy Harter (CEO), Andy Hopper (Chairman) and Tristan Richardson (Chief Architect), are graduates. The Raspberry Pi Foundation has a similar pedigree. Founder Eben Upton, who now serves as CEO of the Foundation's trading subsidiary, was a graduate student at the Computer Laboratory; founders Alan Mycroft and Robert Mullins remain academics there.

RealVNC and the Raspberry Pi Foundation are committed to nurturing the technical skills of the next generation of young engineers. RealVNC's remote access software has been built in to the Raspberry Pi since its September 2016 OS update, ensuring that educational and home users can freely benefit from remote access without having to install or configure additional software.

In support of the long-standing relationship between the organisations, RealVNC will once again attend the annual 'PiWars' robotics competition, to be held in April 2017 at — naturally — the Computer Laboratory. This robotics competition invites students and computer experts alike to compete in various challenges, earning points and winning prizes along the way.

RealVNC's software plays an important role in the use of the Raspberry Pi as an educational tool. Students can choose to run the Raspberry Pi 'headless' (not plugged into a monitor), and access it remotely using the Mac, Windows or Linux computers the school already owns. By doing this, they eliminate the cost and administrative overhead of providing dedicated monitors, keyboards, mice and other peripherals, while retaining the benefits of the Raspberry Pi as a platform for experimentation and digital making.

In classrooms without existing hardware, teachers can instruct students to connect via their own mobile phones or tablets using the free VNC Viewer app.

RealVNC's software is the first and so-far only remote access solution for the Raspberry Pi to support programs which use hardware-accelerated overlays to display their output. This makes it possible to play Minecraft, view camera output, or access the Raspberry Pi's text console remotely.

Developed by Mojang specifically for the Raspberry Pi, Minecraft Pi Edition introduces learners to the Python programming language in a fun way; the Raspberry Pi camera is widely used by community members to control robots and create other interesting projects; and the text console allows users to interact with their device at an advanced level. Without overlay support, many Raspberry Pi users have previously missed out on these advanced features. Now, they have straightforward visual remote access to them.

Premium RealVNC features such as end-to-end encryption are provided free-of-charge on the Raspberry Pi. This allows every student and home user to enjoy safe, secure remote access to their device.

There are many parallels between the Raspberry Pi Foundation and RealVNC. The Raspberry Pi team is doing amazing work in the educational space, and RealVNC are proud to support this with their technology and expertise.

While both organisations are evolving and growing in different ways, their roots remain firmly entwined with Cambridge University's Computer Laboratory.

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*More information about PiWars 2017 can be found at [piwars.org](http://piwars.org).*

# Who's Who

**Yury Audzevich** (RA16) is working at ARM as a design and verification engineer.

**Louise Auger** (CAI MA98) has joined Eastpoint Software as Head of User Experience.

**Dave Barker** (Q BA80) has been appointed Global Product Manager at Workforce Software.

**Alex Bate** (R BA16) is working at Amazon's Development Centre where he is a software development engineer.

**James Brady** (F BA05) has been appointed Director of Engineering at Teespring.

**Harry Cameron** (JE BA11) is a software engineer at Google in London.

**Daniel Chatfield** (R BA16) has joined Monzo Bank as a software engineer.

**Matt Clifford** (MA08 MSc09) was awarded an MBE in the Queen's Birthday Honours 2016 for services to business.

**Peter Cowley's** (F MA77) portfolio continues to grow. His is an investor at Dogtooth Technologies where he is also a board observer.

**Tom Craig** (MA06 PhD09) has been appointed a senior software developer at FIS.

**Achala Deshpande** (F Dip85) is working at Southwest Airlines in Dallas as a senior software engineer.

**Darren Edge** (BA04 PhD08) has been appointed UX Architect at Microsoft Research Special Projects.

**Nicholas Edwards** (BA03 MBA11) has joined Minecraft at Microsoft as a senior franchise business manager.

**Raoul Fleming** (SID MA96) has recently joined T-Systems, near Paris, where he is a portfolio director.

**Andrea Gaglione** (RA16) has joined Digital Catapult.

**Chris Galley** (CC MA87) is acting as an advisor for Park IT Solutions.

**Liam Goddard** (CHU BA04) is now working at Agilitas Private Equity.

**Robin Harrison** (R MA03) is now working at Smarkets as a software engineer.

**Andy Harter** (F BA83 CC PhD90) FREng CEng FIET, has been awarded the Faraday Medal, the most prestigious award of the Institution of Engineering and Technology (IET). The Faraday Medal dates back to 1922, and is awarded for notable scientific or industrial achievement in engineering and for conspicuous service rendered to the profession. Andy is CEO of RealVNC, which he founded in 2002, and is Chair of Cambridge Network, Fellow of St Edmund's College and the Computer Laboratory.



*Dr Andy Harter*

Dr Tim Constandinou, Chair of the IET Awards and Prizes Committee, said: "The Awards and Prizes Committee was unanimous in recommending Dr Harter for the IET's Faraday Medal. Dr Harter's work has over many years has proven to have wide-ranging impact. This includes leading the development of successful technology such as Virtual Network Computing (VNC),

which has created new markets and brought significant economic and environmental benefits. VNC remains the most popular remote access software as well as the most ported, with over 1 billion copies on more different kinds of computer than any other application. Dr Harter is equally skilled at creating new pathways to commercialisation, pioneering open source without compromising profitability. Through his philanthropy and mentoring initiatives he is supporting others to follow his example."

Previous winners of the Faraday Medal include: Professor Sir Michael Pepper; Professor Steve Furber; Professor Sir Richard Friend; Professor Roger Needham; Professor Sir Maurice Wilkes; Sir Martin Ryle; Sir William Henry Bragg and Lord Rutherford.

Dr Andy Harter said: "It is a tremendous honour to have been nominated for this award. It recognizes a career in innovation and enterprise, during which it has been an enormous pleasure to lead some extraordinarily talented teams of people in research, development and commercialization of advanced systems. It is also a privilege to have been responsible for making substantial technology freely available, which has had significant impact on a global scale."

**Roger Hill** (JN BA85) is acting as a consultant for both Winton Capital and Cognizant.

**Dafydd James** (R BA03) has joined Kobalt Music as portal architect.

**Nakul Khanna** (CAI BA16) is working at Bloomberg as a software developer.

As winner of the WISE Tomorrow's Leader Award, a photographic portrait of **Dr Phebe Mann** (HH MA01) was commissioned and displayed in various universities and institutions throughout the country.



*Phebe Mann portrait*

Phebe's WISE portrait is now located permanently at The David Hockney Building, Bradford College, adjacent to the sculpture of Nobel Prize winner, Sir Edward Appleton. Her WISE Portrait was unveiled on 29 November 2016 at the WISE Event at Bradford College.

**James Montgomery** (EM MEng00) is a principal consultant at Channel Four Television Corporation.

**Sean Moran** (CTH MA05) has joined Synpromics Ltd where he is a machine learning scientist.

**Eduardo Muñoz** (M BA13) recently joined Facebook, in the Greater Seattle Area, as a software engineer.

**Barney Pell** (T PhD89) has been appointed to the scientific advisory board of CrowdFlower. Barney will co-chair the advisory board with company founder Lukas Biewald.

**Laurane Saliou** (MUR BA16) is doing a Masters in HCI at Georgia Institute of Technology.

**Will Shackleton** (R BA16) has joined Facebook as a software engineer.

**Lucas Sonnabend** (CHU BA15 MPhil16) is a software engineer at Improbable.

**Amar Sood** (T BA14) is now working at Equidate.

**Alistair Stead** (G PhD15, RA16) is CTO at Oodle Finance.

**Matthew Toseland** (W BA16) has joined StarLeaf as a software developer.

**Keith Turnbull** (T BA81) has set up K-Sera Ltd, an investment, advisory and consultancy company working with security startups.

**Janet Wang** (MSc06) has left Citi and started Dipsta.com

# Hall of fame news

## ARM

ARM has acquired Allinea Software, a leading provider of debug and performance analysis tools for HPC systems.

## Bango

Bango has received the Innovation in Engagement award at the annual Meffys international awards which measure commercial success and recognise innovation across the mobile ecosystem.

## Bromium

Bromium has partnered with Microsoft to secure Windows 10 using endpoint CPU virtualisation to protect the endpoint and enable automatic detection and response to targeted attacks.

## Displaylink

DisplayLink, the leading provider of USB graphics technology, and Targus, the industry leader that introduced the first universal dual-video docking station to deliver laptop power, today announced the launch of the first USB docking station that is capable of supporting dual 4K2K 60Hz Ultra HD displays (24 bpp colour) over a single USB connection to any laptop.

## DroneDeploy

DroneDeploy has unveiled a new free Drone Mapping Directory to enable businesses to find a drone services provider as easily as finding a restaurant, anywhere in the world. So rather than a business having to buy drones, train or hire pilots to fly them, they can just flip through the profiles on the Drone Mapping Directory, look at examples of maps already created, and connect with the most desirable vendors in their area.

## Global Inkjet Systems

Global Inkjet Systems recently celebrated ten years of inkjet innovation. GIS, starting with four members of staff in 2006, now has 50 employees and is a global leader in industrial inkjet with its products and technology driving thousands of industrial inkjet print-heads worldwide. In 2013 GIS was awarded the Queens Award for Enterprise (International Trade).

## Governor Technology

Governor Technology has been acquired by OneTrust, the leading Global Privacy Management Platform based in the US.

## Hubbub

Hubbub, the UK's leading provider of digital fundraising solutions for the education and nonprofit sectors, is building new momentum after securing \$1m in funds of its own in a Stateside win.

The company secured \$1m in investment through the inaugural VentureClash, a global investment challenge organised by Connecticut Innovations.

The Connecticut challenge involved nearly 200 early-stage digital health and financial technology fintech companies from eight countries, with 11 finalists competing to gain investment to establish their presence in the east coast state.

## Improbable

Improbable is partnering with Google to create an innovation subsidy program, the SpatialOS Games Innovation Program. This will enable games studios to build, deploy and test games on SpatialOS up to the point of commercial release with significantly reduced, and in many cases completely eliminated, SpatialOS usage costs, including cloud computing fees. Improbable hopes that this will promote experimentation, much earlier user testing, iteration of games, and an explosion of new ideas.

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## Jagex

Jagex has opened its first London office in Soho. The move follows Jagex's acquisition by Chinese investors.

Zhongji Holding is now a publicly-listed games company based in China, with Jagex as a central part of its offering.

The new firm has been successfully placed on the Chinese stock market. It is part of the Shanghai Zhongji Enterprise Group

## ObjectSecurity

ObjectSecurity, the security policy automation company, has been awarded membership of CyberTECH's Entrepreneur in Residence (EIR) emerging tech program. ObjectSecurity was selected with seven other companies as part of the first batch of companies admitted into the program. CyberTECH Entrepreneur in Residence (EIR) is a six-month program to build strategic relationships between early-stage companies and CyberTECH's growing ecosystem of partners and stakeholders.

## Raspberry Pi

Sales of Raspberry Pi have hit 11 million since its release four-and-a-half years ago.

## Job listing

January 2017

### Baobab Circle

- *Full stack developer*

### St Mary's School, Cambridge

- *Governor*

December 2016

### Cunning Running Software

- *Software engineer*

November 2016

### TVF

- *IT graduate trainee*

### Cosworth

- *Software developers*

### Converge

- *Front end engineering*
- *Full stack engineering*
- *Hardware engineering*

### Numberfit

- *Mathematics/Science coordinator for children's education social enterprise*

### One Trust

- *Full stack developer*

*If you have a job advert that you would like included in the weekly listing, please send the details (as a word doc) to [cam-ring@cl.cam.ac.uk](mailto:cam-ring@cl.cam.ac.uk)*

# Research Skills course

## Sivo Daskalov: Programming matter

Programming is usually associated with the development of software that defines the behaviour of certain hardware. Have you ever wondered if instead of programming the object's behaviour you could program its shape? If your answer to this question was 'yes', you would be happy to know that you are not the only one — this challenge has been dwelling in the minds of Guo Zhan Lum and his research team. To tackle this task they have developed soft magnetic matter by inserting tiny ferromagnetic and aluminium particles into a soft silicone rubber. Stripes of this material can be rapidly bent to a desired shape through their exposure to certain magnetic fields.

Programming the shape of rubber stripes sounds curious but we wouldn't be featuring this research if it wasn't of great significance to multiple fields of science. The first and most obvious application of the programmable matter is in robotics. Components of this material possess high locomotion and manipulation capabilities and will certainly be embraced by professionals in the field. Other usages of this technology include, but are not limited to, fields like bioengineering and medicine. The authors of the paper have designed a number of robots as an example of possible applications of their technology in practice. Among the examples mentioned is a jellyfish-like robot that not only could swim against the slope of an oil-water interface, but was also steerable. Its tentacles could generate fast power strokes and slow recovery strokes — just like those of a biological jellyfish. The researchers have also developed a spermatozoid-like undulating swimmer. His swimming gait, which was a propagating wave with linearly increasing amplitude, enabled it to swim with the impressive average speed of 11mm/s. The last robot that the authors developed was an artificial soft cilium that could approximate the complex beating pattern of his biological counterpart.

Although the speed of shape transformation and flexibility of the developed approach are groundbreaking, limitations to the aforementioned matter programming technology exist. Firstly, not all possible shapes can be produced and due to their fabrication approach the soft matter stripes have uniform magnitude profile. Another limitation has to do with the achievable scale of the components, more precisely the

fact that current technology does not enable the creation of devices with scale measurable in nanometres. Among possible criticisms of the developed technology is related to the transition between shapes. Several unstable shapes may exist during a given transition which could cause the object to deform into an undesirable shape. This limitation can be moderated successfully through more careful transition planning.

The universal shape programming methodology presented is promising and undoubtedly inspiring. Hopefully, in the future its few limitations will be tackled and its positive features will be further enhanced.

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*The best essays from the Research Skills module of the MPhil in Advanced Computer Science course 2016/2017 are being published in 'The Ring'. This is the first of these essays.*

# Computer Laboratory news

## Annual Report of the Faculty 2015–2016 Selected Highlights

### Personnel

As of October 31st 2016, there were 180 members of staff: 43 academic; 30 academic-related; 4 research fellows; and 103 post-doctoral researchers.

Two members of academic staff were appointed: Dr Hatice Gunes, University Senior Lecturer; Dr Neelakantan Krishnaswami, University Lecturer

### Research

Research grant income in the last financial year was £7.4M, an increase of £0.5M on the previous year.

### Teaching

Growth in undergraduate numbers slightly decreased in 2015; our first year intake was 96 students (103 in 2014). For 2016 the intake is 99 students, an increase on 2015, and close to our planned number of 100. Around 72% have chosen the new Computer Science 75% option. Disappointingly, the number of female students dropped to 15% from 19% in 2015 but we will endeavour to identify ways to improve our gender ratio.

The number of students obtaining a First or II.1 in 2016 rose to 85%

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*The full Annual Report of the Faculty 2013–2014 can be found at [www.cl.cam.ac.uk](http://www.cl.cam.ac.uk)*

## Awards

**Professor Cecilia Mascolo** has been named on N<sup>2</sup>Women's list of ten women who have had a major impact in networking and/or communications.

Cecilia's research interests encompass mobile and sensor systems, mobility modeling, mobile applications and mobile data analysis.

Dr Tristan Henderson of University of St Andrew's said "Cecilia has done seminal work in distributed and mobile systems, especially on social network analysis and sensing all sorts of contexts from location to emotion."

**Dr Mateja Jamnik** received a runner-up award for the Royal Society Athena Prize 2016, during the Royal Society's Diversity Conference on 31st October 2016.

The inaugural Royal Society Athena Prize 2016 recognised individuals and teams in the UK research community who have contributed towards the advancement of diversity in science, technology, engineering and mathematics (STEM) in their institutions and organisations.

Mateja received the award for founding [women@CL](mailto:women@cl), an initiative targeted at computer science which has started to change the culture in computing departments nationwide.

**Two teams from the Computer Laboratory** met with success at Northwestern Europe Contest (NWERC 2016).

Team Metallica was awarded a silver medal while Team mpttpm received a bronze medal.



*Team Metallica*

The NWERC is integrated in the ACM International Collegiate Programming Contest and draws students from colleges and universities throughout Belgium, Luxembourg, Great Britain, Ireland, Iceland, Norway, Sweden, Finland, Denmark, Germany and the Netherlands.

## New appointments

Dr Paula Buttery has joined the Computer Laboratory as a Senior Lecturer. Paula was both an undergraduate and postgraduate student at the Lab, and has transferred from the Department of Theoretical and Applied Linguistics.

Paula is a member of the NLIP group.