The modern subject of segregation in social networks stems from classical studies of residential segregation. This is loosely defined as the extent to which different groups live separately from one another. The research area has now developed into a rich combination of network theory and socio-economics.

A cornerstone model in segregation was introduced by Thomas C. Schelling in 1969. A bounded square lattice is populated with agents with one of two labels. Each lattice site can house one agent, but can also be empty. A tolerance is assigned to the system, such that any given agent is considered ‘unhappy’ if the proportion of their neighbours who possess the same label is less than this tolerance. Any unhappy agents are relocated to the nearest available space where they are happy. Simulations show that Schelling models undoubtedly reach equilibrium in a segregated state, so that large areas are occupied by agents of only one type.

Of course, people do not live in a square lattice, nor is our only social contact with our residential neighbours. We may have housemates who are fellow members of BCCS, but other members of the department live all over Bristol and we know each other quite well - far better than we know the people next door.

It therefore makes sense to study networks of social interactions, replacing the lattice above by a network structure in which the nodes are labelled. Schelling-type models exist for all known network topologies and always result in segregated systems.

Studying segregation in social systems requires a form of measurement - a means of quantifying emergent behaviour in order to monitor the evolution of a system, or in order to compare two systems with one another. In studies of segregation in real-life social systems, we have an intuitive idea of what we mean by “more/less segregated”, but defining this concept mathematically is not straightforward. Indeed, a multitude of indices exist, each extracting a different feature of this complex phenomenon. Classical measures of residential segregation, for example, require geographical data split into distinct regions. It is then possible to measure distribution of race/gender/religion with respect to these boundaries, using concepts such as evenness, exposure, concentration, centralisation and clustering.

In networks of social interaction,
however, we require a segregation measure that functions at the level of the individual: how segregated is a particular person or node in a network? Few such measures exist in the literature, and no definitive measure exists. Some of my current work involves devising a generalised segregation measure, aggregate to the level of the individual, using measures of network centrality such as PageRank. Loosely speaking, centrality is a measure of popularity, and we evaluate the popularity of an individual within their own type with respect to their popularity in the whole population. Social media data will hopefully allow us to gain some insight into segregation using the measures mentioned above, but detailed information about friendships and social influence is not readily available on a large scale.

There is still much work to be done in understanding the structures and dynamics of segregated social systems. My aim is to develop the mathematical toolbox we have, and apply new techniques to available data, testing new measures and models.

There is also still interest in understanding residential segregation, in particular studying the influence of social interaction on geographical location, or vice versa. This involves studying correlations between segregation measures in the social and geographical networks of the same group of agents and developing multiplex Schelling-type models to model such systems.

Finally, when working with data and/or models of social interaction networks, the classical measurements mentioned above may still be fruitful. Such networks are of course not partitioned into districts, but the use of community detection in the population would provide natural boundaries with which to compute many indices, perhaps more meaningfully than with those imposed by administrative areas.


In 2007, Bill Gates argued that in artificial intelligence we are witnessing the birth of a front-runner in the best representatives of modern technology, and that it would not be long before every household owned their own robot. As robotics industries move to provide more advanced commercial products for the home, human-computer interaction is becoming increasingly important. For devices to function effectively, it is vital that their users feel comfortable and relaxed while they perform their tasks. Communication between robots and humans is an important aspect of such interactions and research suggests that employing natural language allows users to feel comfortable while interacting with robots.

For a machine to achieve true autonomy in terms of language, we must understand how we speak as humans. If we can replicate this artificially, a robot might be able to speak to us with a “human-like” understanding of language.

This is not a simple process. Natural language presents itself with many interesting phenomena to grapple with, none more confounding than the notion of semantic vagueness. Semantic vagueness has plagued many great minds within the philosophy community for centuries. We may consider the famous Sorites paradox as an exemplar of the bizarre effects of vague predicates: A single grain of sand does not constitute a heap, but a collection of 1,000,000 grains of sand does. If we remove one grain of sand from a heap, we still have a heap. Applying this argument repeatedly, we would eventually arrive at the conclusion that one grain of sand is a heap.

As an interesting thought experiment this can provide an unending basis for philosophical reflection. However, if we cannot explicitly define vague concepts, how can robots understand and use them? The key lies in the notion of language evolution. Luc Steels, director of the VUB Artificial Intelligence Lab in Brussels, launched a research project in 1995 to investigate a theory for the cultural origins and evolution of human languages and research into this area is advancing every year. Such experiments are based on a so-called language game, describing a full communicative interaction between two embodied agents. One agent, acting as a speaker, formulates an utterance to be given to the other agent (the listener), and the listener updates their conceptual model according to the assertion given to them and the constraints placed upon them by their environment. In experiments, agents evolve a language by playing a succession of language games and, as these languages evolve, they adapt to their environment. This suggests that we define language terms according to what we see in the world around us. The Berinmo tribe of Papua New Guinea use only five basic colour terms and do not have terms which distinguish blue from green. They do, however, use terms which distinguish between different shades of green. It would seem to be good strategy to provide distinction between objects which are encountered frequently and which may benefit from such distinction.

As such we cannot hope to provide a robot with a set of strict language rules by which they can hold a conversation. However, if we view language as an evolutionary adaptive system we can begin to make some headway. If we look beyond the syntax of natural language and build language capabilities on top of conceptual structures, robots can learn (through interactions) to adapt to natural languages. As new words emerge they can be learned, and when they are no longer in use (perhaps because our culture no longer requires them) their definitions can disappear.

And so could a robot really speak like a human? Given the right capabilities, perhaps one day it could learn to.
Outreach @ Festivals

The bizarre non-Newtonian nature of cornflour and water proved a hit at both festivals, with children and adults alike getting their hands dirty as they played with the mixture to make it ‘solidify’ and ‘melt’. While this classic science demonstration has long been a favourite, the Outreach team also had a number of new tricks with which to astound and bemuse this year. Festival-goers were able to extract DNA from fruit, observe the formation of vortices in stage smoke shot from air cannons, create visual patterns from sound waves using tea leaves on a metal plate and polystyrene balls in a tube, make glass ‘disappear’ using the optical properties of glycogen and watch water flow upwards by suffocating a candle in a tray of water with an upturned glass.

The Outreach team also took on other roles at each festival; at Brisfest, the team participated in National Science Association workshops over both days at the festival, while at Green Man the team turned their talents to music, performing a song written by ex-BCCS student Ange Onslow called ‘Third Year Physics Lab Blues’. The first verse of this quantum mechanically orientated ditty is included here for your enjoyment!

“Just like that!”: Chris McWilliams demonstrates the art of showmanship as water flows upwards into a jar.

All in all, the team had a very successful summer and are looking forward to future public engagement projects. Of particular note is their upcoming work with Dr. Dave Glowacki on his continuing Danceroom Spectroscopy project, which has already won the 2012/13 University of Bristol Engagement Award, the 2012 Royal Television Society Digital Innovation Award and an Honorary Mention for the Prix Ars Electronica. By interpreting people as energy fields, this exciting engagement project allows members of the public to influence sound and visuals with their movement.

It’s been a busy summer for the BCCS Outreach team, with members attending Brisfest and Green Man Festival in the name of public engagement. As ever, the activities they ran and performances they gave captured the imagination of the public.

Lewis Roberts takes a hit for the sake of public engagement.