# QMUL People - Dr Mehrnoosh Sadrzadeh

**02 August 2016**

*Dr Mehrnoosh Sadrzadeh is a Lecturer in the School of Electronic Engineering and Computer Science, and an Engineering and Physical Sciences Research Council (EPSRC) Research Fellow. She tells us about her work trying to increase machines' understanding of language in order to improve, amongst other things, the efficacy of our internet searches.*

**Tell us about your work and research interests**

My research is about understanding human language and how people use it to communicate with each other and with the world. The models of language I use are based on vectors, of the kind used in quantum physics; the motivation behind this is that search engines, such as Google, use vectors to be able to predict a user's search query results based on meaning rather than just form, and that the so-called 'entangled' vectors of quantum mechanics give better approximations of meaning than other existing methods. By understanding how these processes work, we may be able to program computers to communicate with us and with each other in a similar ways to how we do it.

**How can Google learn how to communicate with us using quantum physics models?**

We communicate with each other using language. Language consists of words, rules of grammar and sentences. We apply the rules of grammar to words and form sentences. But how do uttering these sentences help us understand each other? Words are very different from rules of grammar, and sentences yet different from either. When using language, we must be employing different forms of understanding at different levels. Scientists of a variety of different disciplines have been trying to find answers to these questions. Amongst them are sociologists, linguisticians, psychologists, but more recently also mathematicians, logicians and computer scientists, particularly those in the fields of computational linguistics, natural language processing and artificial intelligence.

Recent advances made by computer scientists in search engines use the mathematics of vectors. Vectors have been traditionally used in physics to describe the position of objects in relation to other objects. The same system can be used to describe meanings of words in relation to other words. It turns out this actually has been suggested by linguisticians and philosophers of language, notably by Zellig Harris, who was Noam Chomsky's supervisor. In the 1940s, Harris put forward the idea that words that have similar meanings often occur in relation to a same set of other words. For instance, words such as 'cat' and 'dog' often occur close to 'pet', 'stroke', 'feed' and 'furry'.  This idea was formalised using vectors in the 1950s by people from Berkeley and later widely applied to information retrieval and used in search engines.

Now, vectors used in quantum mechanics are more general: they have the ability to  encode the relationships between these other words as well; for instance they can tell us that whenever 'cat' occurs close to 'stroke', 'furry' is also around, but this is less the case for 'dog'. The extended model has the ability to provide a better description of word meanings and to differentiate words from each other, for instance in this example, to differentiate 'cat' from 'dog'.

**Will search engines ever be able to understand our language?**

In order to understand our language, they will need to learn what words and sentences mean and how they are related to each other. Search engines such as Google represent meanings of words by vectors. They also represent meanings of documents by vectors. When we query the internet, Google uses the mathematic of vectors to decide the vectors of which documents are close to the vector of our query. This can be based on something very simple like the angle between the vectors. This procedure is already a huge step forward. But now we need to fill the gaps and get the machines to learn meanings of sentences by building vectors for them.

My research is about extending the vector models of language from words to sentences. It is surprising, but high-level mathematical models of quantum mechanics have become very useful here. We use a procedure called ‘quantization’, first pinned down by Sir Michael Atiyah in topological quantum field theory. The reincarnation of this idea in language is that, whereas we cannot form vectors for sentences directly, because they are not repeated enough times in a document, we use the grammatical structure of the sentence alongside the vectors of its words. The findings of my colleagues and me show that one can transform the rules of grammar into operations that act on the vectors of words and produce vectors for meanings of sentences. As a result, we are able to build grammar-aware vectors for sentences and use them to better the search engines.

**What is it about language that interests computer scientists?**
Computer scientists, particularly those in the field of artificial intelligence, would like to enable computers to understand language so that they become able to communicate with us like we communicate with each other. But also, so that computers become able to help us perform language-related tasks faster and better. Examples of such tasks are reading articles and summarising them, classifying articles based on their topic, searching documents to see if they are related to a specific topic, translating documents, and so on.

As a result of much recent research in this area, computers have made grand advances in understanding language, witnessed by the success of programs such as Siri and Google's search and translation engines. Whenever we type a query in Google, the underlying search engine browses the entirety of the internet and retrieves for us documents that are relevant to our query. This is something a human or a team of humans cannot do.

**What led to your being interested in developing software that enables computers to communicate with us?**
I have always been fascinated by how our intelligence and our belief system worked and wanted to understand it. Getting machines to do certain processes, like using language, is one way of getting us to really understand these processes. My previous work was on mathematical and statistical models of logics of knowledge and belief. This has many applications in computer science and economics, such as robotics and network security, as well as the study of various kinds of social interactions. It got me interested to actually narrow the application side down and focus on the language and its formalisation through software.

During my PhD, I developed a reasoning system with a minimal set of conditions under which people could gain the wrong belief, true belief and eventually knowledge about the situation they were dealing with. Implementing this minimal set of conditions was very easy and we ended up developing an automated software that could reason according to these and solve puzzles humans cannot do so easily.

The theoretical results were published in journals, notably in the philosophy journal Synthese, Review of Symbolic Logic, and ACM Transactions on Computational Logic. This led to an Engineering and Physical Sciences Research Council (EPSRC) doctoral fellowship between 2008 and 2011, during which I made my thesis more general and applicable to a wider range of situations. At the same time, a world-leading mathematician and mathematical linguist, Professor Jim Lambek from McGill University, brought my attention to the fact that similar reasoning techniques could be applied to model natural language. Together with Stephen Clark (Cambridge University) and Bob Coecke (Oxford University), we managed to use those reasoning techniques to model natural language. This led to an EPSRC Career Acceleration Fellowship being awarded to me and quite a few well cited publications.

**As joint leader of the Natural Language Lab at QMUL, what are the most exciting and challenging aspects of your role?**

We have weekly group meetings where members of the group talk about their research problems and solutions and what they have been thinking about. We also have external invited speakers who come to tell us about their most exciting piece of work, the results that have made a difference and what their future plans are. It is very nice to meet people through science and get a chance to collaborate with them to advance the field. We have organised events such as conferences and workshops, and even a hackathon. Another challenge is attracting good students to the lab and getting serious collaborations with industry going.

**Tell us about your work in public engagement**

I wrote an article for The Conversation about how Wikipedia is using research from the field of artificial intelligence to develop ‘Wikipedia robo-editors’, which can scan articles for signs that there may be spam or incorrect edits present. My research has also been covered by the University of Oxford Inspired Research, University of Cambridge Research Horizons, Technology.org and New Scientist.

**What are your interests outside of work?**

Recently I got involved in outreach activities such as giving talks about women in computer science to high school students. I found these very enjoyable and rewarding. I like checking out recent scientific advances from magazines like Nature and New Scientist. I like travelling and discovering new cultures and places.  I love singing; back in Oxford I was the head of the music society of my college (Wolfson) where my friends and I ran an alternative choir and held concerts for charity. I play the piano, my husband plays the violin and we often play duets together. I also practise yoga and mindfulness and love going wild water swimming.

Top