Research Interests – Prof. Dr. Iain Couzin

Collective behaviour is all around us: we see flocking birds, schooling fish and, of course, our own human society. However, it is also within us – our brain is one of the most remarkable examples of what collective action of cells can achieve. Revealing principles that underlie evolved collective behaviour across scales of biological organisation is the focus of research in my lab. To do so, we study of a wide range of biological systems, from neural collectives to insect swarms, fish schools to primate groups (including humans). We are particularly interested in how collective action can give rise to forms of intelligence that do not exist at the level of individuals.

The study of collective behaviour is, however, challenging. We cannot simultaneously keep track of multiple individuals, and record their behaviour, by visual observation. It can also take us many years to learn to learn the identify of animals within groups. Computers, however, can be programmed for such tasks. We have developed new computer vision algorithms that allow us to track hundreds, or even thousands, of animals simultaneously. Our software also has super-human powers of identification; for example, it can tell the difference between 100 animals, from flies, to fish to rodents, that – to a human – look completely indistinguishable.

This technology allows us, for the first time, to measure and understand social interactions among animals. In doing so we reveal the remarkable properties of collectives. Near-blind army ants, for example, form traffic lanes to minimise congestion on their trails. They also interconnect their bodies to form living bridges, and scaffolding, to allow others to cross gaps or steep inclines. Such “collective intelligence” is not limited to ants, however. In studies of animal groups on the move, such as schooling fish, we discovered that uninformed individuals play a critical role in collective decision-making, promoting fair (democratic) and fast group decisions.

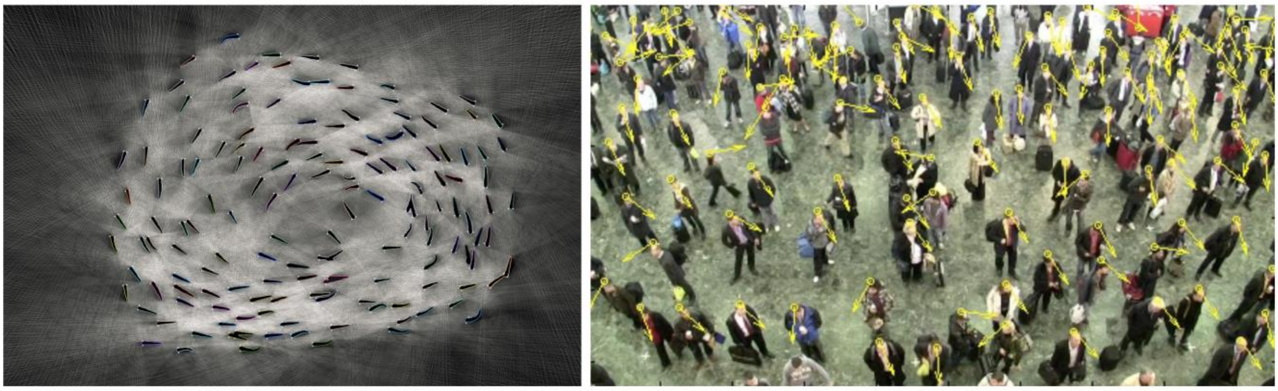
We have also studied plague-forming locusts, one of the ten plagues of Egypt. Even today locusts are estimated to impact the livelihood of one in ten people on the planet via their devastating impact on agriculture. We found that these so-called vegetarian insects are in fact highly cannibalistic. They will march in unison for as far as the eye can see – yet this is no act of cooperation. When they run out of essential nutrients, and especially salt, protein and water, they turn on each other. The highly coordinated swarm is a result of each individual trying to eat the ones ahead and avoiding being eaten by the ones behind. They are effectively on a "forced march" – stop and you risk being eaten.

Recently we have developed immersive "holographic" virtual reality for animals, including for locusts, flies and fish. This allows them to move freely in photorealistic virtual worlds and interact with virtual conspecifics – or via networking of our systems, in what we call "The Matrix", they can interact in real-time with holograms of others. This has enabled us to gain much deeper insights into how the brain represents space and time and uncovered a common mathematical rule for decision-making that is employed by neurons in the brain, and also by animals in collectives, to make fast and smart decisions.

Another important area where social behaviour proves critical is in conservation. Previously we have shown that a small subset of individuals may lead migrations, such as of birds, and also only by grouping can some species effectively respond to important environmental changes. Due to human impact, such as deforestation, urbanisation and hunting many social species are especially at risk. Such species are also the ones we most urgently need to study so we can protect them. We have developed remote imaging technologies that allow us to non-invasively track animals, such as endangered zebra in Kenya. This allow us to understand how their behaviour is impacted by the increasing encroachment of humans as well as climate change. Such data are essential in order to make scientifically-guided recommendations that maximise conservation potential while minimising impact on local human communities.

Our studies have also inspired us to develop robots that move and interact in similar ways to real animals. In doing so we have found new ways for swarms of robots to use "collective intelligence" to effectively explore space and to work together, such as during search and rescue operations.

A hallmark of collective behaviour is the transmission of behaviours, or opinions, among interacting individuals. How this occurs has remarkable mathematical commonalities irrespective of the species – from fish to humans. So even though humans are highly complex creatures, certain aspects of our collective behaviour can be predictable. Furthermore, social interactions are vital for our wellbeing, but as in other social animals proximity comes at the price of increased disease transmission. Seldom has it been so evident that the spread of information, and misinformation, and the formation of often highly-polarised opinions, greatly impact human society. Technology such, as social media, has greatly accelerated changes to our social systems. Yet we still have a poor understanding of the consequences of such fundamental changes in communication. Further studies of our collective behaviour is, therefore, essential if we are to ensure stable and progressive societies, and to address ongoing and emerging global crises.



Automated tracking allows us to quantify the behaviour of many animals simultaneously, such as schooling fish (left) and pedestrians in crowded urban environments (right).