Mathematical models able to calculate large group social behaviour

EU-funded mathematicians under the HDSPCONTR project have developed a series of algorithms and mathematical models that can predict and influence the behaviour of social groups.

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There is a long history of research aimed at predicting the behaviour of social groups and influencing their actions but for the most part, mathematical modelling of social systems and dynamics that could achieve these aims has remained out of reach. It seems practically impossible to precisely predict the behaviour of individuals, not least because of the myriad interactions between the physical, cognitive and social domains.

Now, thanks to a team at the Technical University of Munich (TUM), this is now on its way to becoming reality. Reporting the key results of the HDSPCONTR (High-Dimensional Sparse Optimal Control) project at the European Congress of Mathematics in July 2016 and since published in the congress's official 'Proceedings', the project team argues that it is quite different when considering people in traffic, in social networks or at major events. This is because they are appearing as individuals but as part of a crowd.

Influencing group behaviour

In physics, it is not necessary to know the properties of every individual particle to calculate with a high probability the direction of flow of a large number of gas molecules, it is merely enough to understand their mean motion properties. 'We can take the same approach when looking at flows of human masses, animal swarms or interacting robots,' says Professor Massimo Fornasier, Principal Investigator of the project. 'Analogous to the force of attraction between molecules in a gas, we can

describe generalised behavioural patterns as resulting from interacting social forces between individual agents and represent them in mathematical equations.'

Using computer simulations, the mathematicians have shown that they can describe potential collective behavioural patterns of a large number of individuals who mutually influence each other in a given situation. 'In the next step, we can then also make predictions about future behaviour,' comments Fornasier. 'And once we can calculate the behaviour of a group of interacting agents in advance, we are only one small step away from controlling them.'

Fornasier and his team highlighted how their process is amenable to influencing group behaviour by conducting an experiment in collaboration with Italy's National Research Council (CNR) and Rome's La Sapienza University. They assigned two groups of 40 students each the task of finding the specific location of a building. However the researchers planted two incognito informed agents into one of the groups. By merely moving very determinedly in a predefined direction, the agents were able to steer the group towards the target spot.

Overall, the experiment showed that taking control of self-organising systems, which also include groups of individuals, is possible with surprisingly little effort. The team also proved that the results equally apply to very large groups, with Fornasier saying that actually only two or three agents per 100 individuals in sufficient to take control.

Adaptable models

The mathematical models are easily adaptable to a wide variety of social situations (such as evacuating large numbers of people in an emergency or simply for just efficient crowd control) due to the fact they're formulated in an entirely abstract environment. 'But we can also apply our results to other interesting domains in society, like the behaviour of investors in financial markets,' comments Fornasier.

The research team also highlighted how opinion forming in groups also builds on the interactions of people. They showed that it is most effective in their models to concentrate on the most radical defenders of a given opinion, whereby if you manage to convince them, the rest of the group will easily follow.

Limits of predictive models

However, there are limits to the models developed by the HDSPCONTR team. 'An important prerequisite for predictability and controllability is that the myriad possible interactions between the agents in a large group can be reduced to a small number of effective ones,' explains Fornasier. 'Forecasts function well in groups that show generalised patterns of behaviour.'

For those who believe that the creation of such models veers towards the dark predictions found in many science-fiction and dystopian novels, Fornasier is reassuring: ‘An extensive forecast of events like that accomplished by the mathematician Hari Seldon in Isaac Asimov’s ‘Foundation’ series or the all-encompassing control exercised in Aldous Huxley’s ‘Brave New World’ will remain science-fiction.’

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