Swarming starlings help probe plasma, crowds and stock market

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Researchers at the University of Warwick's Physics Department's Centre for Fusion, Space and Astrophysics have found a powerful technique that could be used to detect precisely when ordered patterns form in everything from plasma in the solar wind and fusion reactors, to crowds of people, or flocks of birds. The technique could even be used to find unusual patterns in stock market behaviour.

The researchers began their work in a research group interested in plasmas. These are difficult to study at the best of times because the opportunities to view plasma in the solar wind are limited by the small number of satellites observing such things and plasmas in nuclear fusion reactions are obviously not easily accessible.

The University of Warwick researchers were particularly interested in how complex systems such as plasma, crowds of people, or flocks of birds suddenly move from a disordered random state to an ordered one. To crack this problem they developed a technique that combines an earlier study of the flocking behavior of large groups of birds and insects with information technology used to correlate information from a range of parallel signals.

University of Warwick physicist Robert Wicks hit upon the idea of using an information technology tool called mutual information that can detect patterns and correlations from a very small set of points (typically 10 within a large system). In theory he believed that this method would be much more accurate than the normal statistical analysis of such dynamic

systems such as crowds or plasmas and it should be particularly good at picking up the “phase transitions” from disorder to order in such complicated systems.

Initially the researchers were stumped as to how to test this theory. The very complexity (and often inaccessibility) that caused the observation problems they were trying to overcome meant there was no accurate real world date set to check their new technique against.

The solution came from the work of Hungarian researcher Tamás Vicsek, Professor of Physics in the Department of Biological Physics of Eotvos University, Budapest. An expert in the flocking behaviour of birds and insects.

Professor Viscek had devised a simple model to replicate the flocking behaviour of colonies of bacteria or large groups of birds and insects such as flocking starlings or swarming locusts. The Warwick research team recognized that the patterns model produced the same sort of order to disorder phase transitions that would be an ideal test for their mutual information based tool.

They applied their “mutual information” based technique to a Viscek model sampling the “signal” from a small number of points within the model and compared their technique to traditional statistical tools used to examine the behaviour of such dynamic systems. They found that in terms of error rate their “mutual information” based technique was four times better than traditional methods in understanding how and when these systems moved from disorder to order.

The new tool has obvious benefits in opening up new understandings of plasmas, crowds and flocking birds and insects but the University of Warwick research team think it could also be used for stock market analysis

The technique is particularly good at uncovering clumping of particles, movements from order to disorder, and correlating the performance of several points within a dynamic system. Taken together if the technique was applied to stock market shifts it could uncover patterns of clumping in the moving of different stocks. This could help market analysts uncover new and unexpected market connections and mutual dependencies between companies that had no obvious connection yet seem to share similar movements in share price.

The research has been published in a paper entitled: "Mutual Information as a Tool for Identifying Phase Transitions in Dynamical Complex Systems With Limited Data" published in *Phys. Rev. E* 75, 051125 (2007)

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