Western Science

Department of Applied Mathematics

Applied Mathematics Colloquium

Date: Wednesday, November 9, 2016 ; Time: 2:30 – 3:30 p.m.
Location: Middlesex College Room 204

Critical transitions in coupled behaviour-disease systems: applying dynamical systems theory to data science problems

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Abstract:Data science is a field of growing interest amongst both the public and scientific communities. However, data science methodology does not use the insights of dynamical systems theory as much as it could, compared to widespread applications of conventional statistics. In this talk I will describe an application of dynamical systems theory to a data science problem. In particular, vaccine scares are of great concern to population health, because they can enable renewed infectious disease outbreaks and delay global eradication by many years. Vaccine scares often entail coupled dynamics between social vaccinating behaviour and disease transmission dynamics that can be captured by simple systems of nonlinear differential equations. These equations exhibit bifurcations that are often termed "critical transitions", where the state of the system shifts abruptly to a contrasting state as a parameter is moved beyond a bifurcation point. While apparently occurring without warning, in stochastic systems these transitions are often preceded by an increase in time series autocorrelation and variance prior to the transition, caused by the dominant eigenvalue approaching zero. Therefore, it is possible that critical transitions may be predicted ahead of time by such early warning signals. If vaccine scares can be modelled as critical transitions, then we may be able to predict them by looking for early warning signals. In this talk I will describe and characterize some theory for critical transitions and early warning signals in coupled behaviour-disease systems. I will also present analyses of data during the 2014-15 Disneyland, California measles outbreak. The data consist of time series of measles-related Google searches, and measles-related tweets that have been sentiment-classified into pro- and anti-vaccine tweets using machine-learning algorithms. The data reveal the telltale signatures of early warning signals before the 2014-15 Disneyland, California outbreaks. Such methods may improve the ability of health authorities to anticipate growing vaccine refusal, and focus messaging strategies accordingly. We suggest that data science can benefit from greater interaction with dynamical systems theory.