Medical Xpress

Every cloud has a silver lining: Weather forecasting models could predict brain tumor growth

December 21 2011

Ever wondered how meteorologists can accurately predict the weather? They use complex spatiotemporal weather models, i.e. mathematical equations that track the motions of the atmosphere through time and space, and combine them with incoming data streams from weather stations and satellites. Now, an innovative new study published in BioMed Central's open access journal *Biology Direct* has determined that the mathematical methodology used to assimilate data for weather forecasting could be used to predict the spread of brain tumors.

The authors from the Arizona State University and the Barrow Neurological Institute, Arizona, USA, wanted to prove that mathematical methods used in weather prediction could be useful in clinical situations – not just in brain cancer, but also in other cancers and diseases. They chose to study glioblastoma multiforme (GBM), a malignant brain cancer.

GBM is the most common and most aggressive type of brain cancer. Despite treatment, average patient survival is less than 15 months from initial diagnosis, and it is largely resistant to chemo- and radiotherapy. GBM can quickly invade large, sensitive regions of the brain, which makes it almost impossible to remove via surgery and almost certain to recur afterwards. Because little progress has been made in this area, GBM is an important area to study, and is a particularly good cancer against which to test a mathematical model, as its dynamics involve complex geometry.

In addition to setting out to prove that good quantitative predictions of GBM growth and spread are possible, the authors wanted to provide uncertainty estimates. An algorithm previously developed for numerical weather prediction – a modern state estimation algorithm known as a Local Ensemble Transform Kalman Filter (LETKF) – was applied to two different mathematical models of the growth and spread of glioblastoma. Synthetic magnetic resonance images of a hypothetical tumor were used for this purpose.

Data assimilation techniques were then used to update the state vector, i.e. the initial condition of the glioblastoma growth model, by combining new observations with one or more prior forecasts. They then measured the feasibility of the model in individual patient cases for making short-term (60-day) forecasts of GBM spread and growth.

Despite this being a preliminary study, the authors were successful in demonstrating the feasibility of LETKF for short-term, clinically relevant predictions of the growth and spread of malignant brain tumors. LETKF forecasting and data assimilation provides an accurate and computationally efficient way of updating the initial condition (state vector) of a complex spatiotemporal model with new quantitative measurements. The intelligent model can also take into account likely errors in model parameters and measurement uncertainties in magnetic resonance imaging.

Mark Preul, one of the leaders of the study, believes that LETKF should be considered for future efforts that use mathematical models for clinical purposes in individual patient cases. He said, "Though work remains before our approach can be seriously considered in clinical settings, an accurate forecast system for glioblastoma may prove useful for treatment planning and patient counseling."

More information: Accurate State Estimation from Uncertain Data and Models: An Application of Data Assimilation to Mathematical Models of Human Brain Tumors. Eric J Kostelich, Yang Kuang, Joshua M McDaniel, Nina Z Moore, Nikolay L Martirosyan and Mark C Preul *Biology Direct* (in press)

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