Can Nonlinear Dynamics Improve Medical Diagnostics?

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Medical diagnostics is a very difficult problem as evidenced by the large numbers of errors committed even by the best experts and in the best of circumstances. In the US alone, more than 160,000 deaths occur every year because of diagnostic errors. Of the many possible reasons for this dire situation, the primary one is that the human body is a complex, nonlinear dynamic system of systems. It is of course well known that there are many enduring mysteries that will take many years to discover. Notwithstanding that, there are many possible opportunities to exploit our *present* understanding to make diagnostics better. This talk will hence focus on the relevance of nonlinear dynamics to medical diagnostics.

We will first provide a brief overview of our research over the past 15 years using signal processing and machine learning (ML) to several important problems in medical diagnostics including brain damage, intubation and cardiopulmonary resuscitation. The typical algorithm development will be explained with reference to example problems. Importantly, the *limitations* of such approaches will be discussed.

As opposed to ML that simply learns from data and provides limited insight, nonlinear dynamics has been historically used to explain many important phenomena in the human body, and has the potential to mitigate limitations of ML. In research collaboration with medical experts, we have been passionately driving to develop robust diagnostic algorithms by exploiting the powerful predictive power of nonlinear dynamics. We will discuss these approaches and results from our early efforts in diagnostics and outline future research directions with the hope that this talk will generate new and exciting discussions.

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Bio-sketch of 'Nat' C Nataraj

Dr. C. Nataraj (Nat) holds the Moritz Chair Professorship in Engineered Systems and is the Founding Director of the Villanova Center for Analytics of Dynamic Systems (vcads.org) at Villanova University. Nat's research expertise is in dynamic systems modeling, analysis and diagnostics with applications to machinery, robotics and biomedical systems. Nat has served as Chair of Department of Mechanical Engineering, and as the founding Director of the Center for Nonlinear Dynamics & Control. He has taught over 23 courses, has published a textbook in *Vibrations* along with numerous papers, and holds three patents.

Nat is a Life Fellow of ASME and a Senior Member of IEEE. He is the Editor-in-Chief of Springer-Nature *Journal of Vibration Engineering & Technologies* and serves as the Nodycast editor for *Nonlinear Dynamics*. Nat's research has been funded by ONR, DARPA, NSF and NIH. His research has received national media attention including a TEDx talk and articles in Philadelphia Inquirer, US News and World Report, Forbes and Wired Magazines.