Applications of Complexity Theory in Medicine

Course Program

Lecturer: J. Marczyk PhD

Course Description:

Because modern science lacks a holistic and systemic perspective favouring super-specialization, a patient is rarely seen as a multi-organ dynamic system of systems. Because of the overwhelming complexity of the human body, only on rare occasions is medical science truly quantitative. The goal of Quantitative Complexity Management is to provide the medical community with a quantitative and systemic perspective of the state of a patient, as well as on the impact of treatment.

The course introduces complexity from a quantitative perspective, in opposition to the traditional approach, whereby complexity is a process, not a property of systems. Numerous applications are illustrated. A workshop with practical exercises concludes the course.

Course participants will be able to appreciate and understand the importance of a systemic and nonlinear approach to data treatment in the context of medicine as well as the fundamentals of a quantitative treatment of complexity.

Course Structure:

The course shall be divided into 8 parts, each comprising two lessons of 45 minutes each. The content of the course is the following:

PART 1

1. Fuzzy Cognitive Maps
2. Input/Output mapping in dynamical systems
3. Monte Carlo Simulation
4. Graphs, maps representations
5. Canonical Decomposition of systems

PART 2

6. Correlations (Pearson, Spearman)

7. Visual Analytics

8. Entropy: information, disorder, Shannon's equation

9. Second Law of Thermodynamics

PART 3

10. Complexity, conventional approach (no metrics), emergence, self-organization, self-organized criticality

11. Quantitative approach to Complexity, definition and metric, $C=f(N; S; E)$,

12. Complexity bounds, Critical Complexity, minimum complexity, $S=0$, $E=0$

13. Complexity Profiling

14. The Complexity Map

PART 4

15. Software tools – OntoSpace™, OntoTest™, OntoNet™, live demos

16. Applications of complexity (economics, finance, manufacturing)
    a. Anomaly detection
    b. Early warnings

PART 5

17. Applications of complexity in medicine:
    a. Cardiology
    b. Neurology
    c. Intensive Care
    d. Pharma

e. Multimorbidity
f. Epileptic seizure

PART 6

g. Measuring the Impact of Therapy
h. Measuring patient's stability (dC/dt)

PART 7

18. Workshop, exercises

PART 8

19. Literature, further reading

20. Future research and projects:

a. Protein folding
b. drug complexity

Contact Information for subscription

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Lecturer Biography:

Jacek Marczyk is an ex-rocket scientist with forty years' experience and author of various books on simulation, data analysis, uncertainty, and complexity management. Following his work in the aerospace industry he has developed in 2003 the Quantitative Complexity Theory (QCT). In 2005 he founded Ontonix, where he leads all R&D projects. He currently focuses on QCT-based Artificial Intuition, a next-gen version of Artificial Intelligence that doesn't require Machine Learning.

Dr. Marczyk holds an MS in Aeronautical Engineering (Politecnico di Milano, 1983), MS in Aerospace Engineering (Politecnico di Torino, 1986) and a Ph.D in Civil Engineering (Universidad Politecnica de Catalunya, 1998). During his career he has held various executive positions, working at companies such as Airbus Space Division, BMW AG, Centric Engineering Systems, Tecnomare, ESI, Silicon Graphics and MSC Software.