Abstract of the dissertation.

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Abstract

Our world is complex. This complexity is the result of the interactions among socio-political-economic-environmental factors, the multitude of potential relationships between the individual components and the multiplicity of elements involved. It can be grasped by the "amount " of information needed to describe a system: the more complex a system is, the more information is required to describe it. On the other hand, we cannot know all the components of the system or how the components are connected to each other. Any given system with high complexity at the microlevel needs many variables to describe it. But it is no longer certain that at the macro level the complexity of the same system remains the same, so it is possible that it can be described with much less information.

Complex systems are observable in our everyday lives in many ways, for example in the living cells, the Earth's climate, the communication systems, the human relationships, stock markets, or economic markets**.** These examples cover several scientific disciplines. An interdisciplinary approach can be achieved when we work across disciplines to solve problems. The methods and concepts of complex systems can be applied to a wide range of fields in society and economics, biology or robotics. Up to nowadays, the lack of computing capacity and the inability to acquire and process large sets of data prevented the detailed exploration and simulation of such systems. Recently, the availability of digitized data has increased. This opens the possibility of studying areas such as the behaviour of individuals within a group, the analysis

of web traffic, user feedback, stock market transactions etc. As a result, new models can be built and tested for emerging collective phenomena. In my dissertation, I researched human behavioural patterns with the help of the investigation methods of complex systems. There are now various sources of data available to support such research. I decided to use geo-referenced posts from the billion wide Twitter's database, stock market data, custom reports, and user complaint messages from these data sources. With the help of the Internet, billions of people use various online community platforms to maintain relationships. Users send messages, comments, join specific groups, read and respond to the news, leave behind digital footprints. Collecting this information is critical for building successful models of complex systems. Digital human footprints often contain sensitive data. After careful anonymization, encryption and aggregation, meaningful insight can be gained into human behaviour without violating anyone’s rights. However, the understanding of socio-economic phenomena does not merely stem from data collection, as it lacks structural insight and context and does not explain patterns that have been identified. The existing models that describe patterns of human behaviour often rely on earlier concepts of complexity theory. Therefore, in a new approach, methods should be developed that link microscopic data to macroscopic observations. Then, the results of these methods need to be evaluated, scaled, and compared. In this thesis, I would like to contribute to the evaluation of human footprints in digital data with the ultimate goal to learn more about the forces that are moving humanity.

At the beginning of the twenty-first century, the business and economic environment in the world changed significantly. The world is organized into a single complex, global market. With the expansion of online markets, capital can be immediately transferred from one place to another. Small changes can multiply very quickly in this market and lead to dramatic changes. Technical development is swift, so the competitive position of companies is continually changing. Market movement is inherent in everyday life. In such economic circumstances, we

can understand what is happening around us better through chaos and complexity theory, than through traditional economic theories. Theories of chaos and complexity act as a real challenge to conventional economic theories and question traditional interpretations of economic equilibrium.

The study can be summarized in the identification of **one comprehensive and homogeneous approach that has been applied to five subareas**.

In general, the developed models rely on methods that link microscopic data with macroscopic observations. I evaluated, scaled, and compared the results of these methods, hypothesizing that, based on the methods used in the papers, we understand social reality better through chaos theory.

With respect to the five subareas:

- I have observed the development of a football team based on changes in order to study phases of a complex system. I hypothesize that understanding the motivations of smaller groups in the team and successfully integrating this knowledge to understand higher-level elements will facilitate understanding the complex transitions in a more extensive system.

- One way to understand stock market movements is to interpret the stock market as a complex system. I have highlighted the features of complex systems in the two different articles to show how small changes in the input can cause significant changes in the output. In my predictions, the goal was not to give an accurate estimate of what would happen in the future. The aim was to outline realistic scenarios, alternatives that could point out the way for the future. I hypothesize that there is a group of individual investors whose decisions about investing in a football club are driven not only by considerations of their long-term well-being but also by their daily emotional state related to the clubs.

- One of the basic assumptions of economic theory is that economic actors always act rationally However, there are significant problems with applying this assumption as we observe that some events have a greater impact on the market than we would expect. Because of this fact, one needs to pay more and more attention to nonlinearity issues. For example, today the big innovative companies have taken advantage of the web. When innovative products are created, the users of these products have to adapt to new challenges. They need to be familiar with the digital world. I hypothesize that there is a link between the frequency of the appearance of these companies in social media and the volatility of stock prices of these companies.

- The network of football fans also forms a complex system. Complexity is referred not only to the background but also to the methodology. Using the power of computing, I can prove relationships among the components of the system that help to understand better the whole system. By using modern technical equipment, significant events related to the biggest football clubs can be tracked from anywhere. In this direction, mapping the background of these clubs in order to understand the motivations of their supporters plays an important role. By using the urban scaling theory, I measured how the size of a city relates to the number of football fans, hypothesizing that the lower is the GDP of a country, the more fans live in cities. The results of the study can be supplemented by the smart device usage habits of the people living in the given area and the internet coverage may differ between towns and villages in countries with lower GDP.

- The IT infrastructure also forms a complex system. In enterprise environments, the analysis of failure phenomena connected to this infrastructure is paramount. Complexity usually assumes some sort of hierarchy. The components of the system at a certain level of the hierarchy can interact with each other. What makes complex systems interesting is that as a result of the interactions between their parts, the behaviour of the parts changes in such a way that the whole system follows a qualitatively new pattern of behaviour. Analysing bug reports can help to find broader relationships across systems. I hypothesize that usage of semantic analysis with other data mining techniques can help to find the focus, patterns and trends in the texts connected to user feedback.