STSM by Vladimir Jaćimović (University of Montenegro)

**Continuous-time dynamical systems for deep learning**

at Friedrich-Alexander University Erlangen-Nuremberg (prof. Enrique Zuazua)

**Background information:** With an explosive growth of neural networks and enormous number of their applications, there is a need for a novel conceptual approaches to machine learning. These approaches often require use of previously developed mathematical methods and theories. In particular, ideas from mathematical control theory have been employed in order to propose new architecture of neural networks. One of recent research directions of prof. Enrique Zuazua and his group is in the field of applications of the control theory to deep learning. The group of prof. Zuazua has a great experience in control of ODE’s, PDE’s, including numerical methods, which can be relevant for deep learning. On the other side, prof. Vladimir Jaćimović with his students at the University of Montenegro has initiated the work on some novel approaches to machine learning, based on ODE’s and game theory.

**Goals of the Short Term Scientific Mission:** The goal of this STSM was to find potential points of common interest and cross-fertilization of different ideas from both sides. In particular, it has been discussed how evolutionary games and mean-field games can be used for training of neural networks.

**Results of the Short Term Scientific Mission:** Several potential topics and ideas for the future joint research have been identified. In particular, both sides have recognized a potential of game-theoretic approaches (in which games are described by ODE's and PDE's) for machine learning. It has been agreed to continue cooperation and exchange of ideas. Moreover, on October 18th prof. Jaćimović exposed some of his ideas in the talk “Natural gradient in evolutionary games” given at the seminar of Group for dynamics, control and numerics at FAU Erlangen-Nuremberg (FAU DCN-AvH).