## Abstract

**Title**: *Evolutionary algorithms in sequential Stackelberg Security Games*

The thesis examines the possibility of applying evolutionary algorithms for approximating equilibrium in sequential Stackelberg Security Games. Security Games are played by two non-symmetrical players called the Defender and the Attacker. The Defender commits to his/her strategy first and after that, the Attacker chooses his/her strategy knowing the opponent's strategy. The goal is to find Stackelberg equilibrium which is the pair of the players' strategies that fulfill the following condition: changing strategy by any player will lead to his/her result deflation. It was proven that for the class of games considered in this thesis finding Stackelberg equilibrium is an NP-hard problem.

Stackelberg Security Games have significant practical relevance and they are widely implemented in real-world applications, for instance for airports surveillance, poaching prevention in Africa, or ferries protection in Boston Harbour.

The most common approaches in the literature base on Mixed Integer Linear Programming (MILP). However, they are ineffective in terms of computational complexity and memory consumption which makes them insufficient for larger games.

This thesis proposes a novel algorithm based on biological evolution which explores the results space by maintaining a population of candidate solutions. The effectiveness of the described approach is verified in a series of experiments that cover a wide class of test games with various characteristics and difficulty levels. Obtained results show that the proposed method, in the vast majority of the cases, returns solutions that are optimal or very close to optimal. At the same time, the method demonstrates better computation time scalability and lower memory consumption which allows solving bigger and more complicated games. Another advantage of the proposed algorithm is its generality and ease of adaptation to various game variants such as games with limited observability, games with bounded rationality of the Attacker, or games with observational uncertainty.

The thesis presents a deep analysis of the proposed approach, comprehensive experimental evaluation of various algorithm modifications and comparison with state-of-the-art methods from the literature. Moreover, two extensions to the baseline algorithm are proposed: artificial neural network utilization (neuroevolutionary approach) and competing population incorporation (coevolutionary approach).

Demonstrated experimental results show that the application of evolutionary algorithms to Stackelberg Security Games offers a number of advantages and is a viable alternative to other currently used methods.

**Key words**: *evolutionary algorithms, Security Games, Stackelberg Equilibrium*