A simulation of medieval battlefield as use case of cellular automata.

Agent systems course project

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Agent systems are computational models, which use so-called agents as base units. Agents within the systems are entities which are able to interact and perform various user defined actions in the simulated environment. The behavior of individual agents is dependent on the current state of environment, i.e. the presence or actions of other agents. Due to these properties, agent systems can be used to simulate complex and emergent systems. The system is defined as complex when it is composed of multiple microscopic components that interact in non-linear fashion [1]. Crucial feature of a complex system is that it can present emergent behavior at macroscopic level [1]. Emergence can be understood as development of a system's behavior that is manifested in macro scale and cannot be simply explained by inspection of microscopic properties [1]. A special case of agent-based systems are cellular automata, a group of systems that simulate complex system behavior by changing the model's internal state based on its previous state [1]. The simulation usually takes place in discrete time and space.

Bering this information in mind, we can therefore simulate and explore various complex systems. One such case of complex systems that can be simulated via cellular automata is a battlefield. In these systems, individual micro-scale agents (soldiers) interact with each other to change the state of the battlefield and reach the final state (the end of the battle). The outcome of the battle cannot be determined only by examination of a single unit. The macro behavior changes based on the agent's interactions, therefore this problem matches the criteria of complexity and emergence. To simulate this problem, the cellular automata concept can be extended from discrete space to continuous space [2]. This extension provides more precise control of the unit's behavior and leads to a simulation that mimics the real life scenario better.

The simulation can be created using many modern programming languages. We decided to choose Python due to simplicity of usage and a wide range of helpful libraries available. One of the libraries - Mesa [3] - provides useful tools specific for agent-based system modeling. The battlefield will be simulated using continuous spatial automaton, with units interacting with each other in discrete time. The main work will focus on effective description of unit parameters and their behavior. Performance wise, the computation speed can become a bottleneck of this solution. When scaling, the model can become computationally expensive, therefore multiprocessing and/or GPU computations will be considered to provide smooth display of the battlefield.

References

[1] Sayama H. *Introduction to the Modeling and Analysis of Complex Systems*, Open SUNY Textbooks, 2015

[2] MacLennan B. J. *Continuous Spatial Automata*, 1990

[3] Mesa, a Python library for simulating agent-based systems *https://mesa.readthedocs.io/en/latest/index.html*