

Poznań University of Technology
Faculty of Computing Science
Institute of Computing Science

Master's thesis

**ROAD TO SOLVING QUADRATIC ASSIGNMENT PROBLEM
USING PHYSARUM MACHINES**

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Poznań, 2016

Acknowledgements

The scientific man does not aim at an immediate result. He does not expect that his advanced ideas will be readily taken up.

*His work is like that of the planter — for the future.
His duty is to lay the foundation for those who are to come,
and point the way.*

NIKOLA TESLA

Abstract

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Chapter 1

Introduction

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1.1 Motivation

The motivation for this thesis was indirect interest in topics related to computer science, but also of the world around us. The behavior of physarum, which is often compared to a simple machine, creates many opportunities to unveil a biological side of computer science making the topic fascinating.

Nowadays, scientists put great emphasis on discovering and analyzing the nature. It is done to improve the world surrounding us. Generally, two ways of development of this field of study could be distinguished. The first one focuses on improving the biological flaws of humans and animals. A good case is studies related to the creation of natural prosthetics that make life easier for the people without limbs. The second one is a transmission of the known naturally patterns to the computing environment. Observing the nature leads to logical algorithms, which usage can solve issues seemingly unrelated to originally presented problems and often gives much better solution than working it out greedy. For example, thanks to such research, the ant algorithm was implemented, which shows the behavior of an ant colony searching for the best path between their home and food. These unconventional methods of inventing algorithms allow excellent results for hitherto very complicated mathematical problems.

The physarums have great potential in both, the first and the second case. Until now, several studies linked to these organisms were conducted, though, it still remains a mystery to many experts. One example of an experiment carried on slime molds was solving the maze. The organism found the shortest path between two oatmeals in the environment with walls, thus finding the solution for the maze. More detailed description and more cases are presented in the later chapter of this thesis. Nonetheless, these interesting achievements were the reason behind the choice of the subject.

Also, the thesis focuses on the quadratic assignment problem, which is a challenging topic. It reflects the real difficulties faced by the managers of logistics companies. They need optimal results, however, the complexity of the dilemma makes it almost impossible to resolve in a reasonable time. This demand urges scientists to explore this issue further and try to look for a reliable way of solving the problem.

The QAP could be a great challenge for inventing a new unconventional algorithm based on the behavior of physarum.

1.2 Goal

This thesis presents the road to solving quadratic assignment problem (QAP) using physarum machines. In order to reach meaningful conclusions, it is needed to analyze deeply each part of the main dilemma.

The first task is to carry out the detailed investigation of the behavior and capabilities of physarum. Without the understanding of organisms, it is not possible to replicate its operations. For this purpose, the living physarums will be observed and described, which will mainly consist of the schemas of ways of moving to find food. This will be studied in order to extract similar patterns and facilitate the creation of their mathematical model, which could be transported into the computer environment. Additionally, it will determine whether they fit into QAP.

Furthermore, not only the direct observation of their behavior is needed here, but also a careful examination of previous studies. It will show already discovered characteristics, which could have been unnoticed on our own research.

In order to properly inspect the organisms, there must be implemented a method, which facilitates observations. The physarum are moving gradually and changes may not be always noticed by a human being. For this reason, the digital camera will be used. Later, the recorded image will be interpreted by a computer. This way the description of changes over time will be more accurate, which allows for more specific description of physarum's behavior.

Next, the analysis of the research related to the QAP will be required leading to better understanding of the problem and showing the current practices for resolving it. Recognizing the dilemma will make it easier to fit algorithm based on slime molds to the QAP.

The key element of this thesis is applying physarum methods for solving QAP. This step will consist of adapting the mechanisms, implementation of simulation and reading its results. It will summarize the previously acquired theoretical knowledge in a practical task.

And last, but not least, our aim will be to create the innovative method for solving QAP.

1.3 Chapters

The thesis is divided into five chapters and includes one appendix.

- Chapter two describes the physarum organisms characteristics such as a position in the hierarchy, basic information about the species, basics of operations, emerging behavior and previous research.
- Chapter three outlines the quadratic assignment problem (QAP). It consists of a different interpretation, practical usages, current exact solution and current heuristic.
- Chapter four presents the algorithm, which will be proposed as the result of this thesis. It will be a pseudophysarum machine providing working metaheuristics based on observed behavior.
- Chapter five summarizes the research and is focusing on future work ideas.
- Appendix A includes description of hardware-software platform, which is used for examination of physarum.

Work Distribution

Chapter 2

Physarum Polycephalum

Chapter 3

Quadratic Assignment Problem

Chapter 4

Algorithm

Chapter 5

Conclusion

Appendix A

Physarum-Computer Interface



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Typeset using L^AT_EX in Computer Modern.

BibT_EX:

```
@mastersthesis{ key,  
  author = " Amadeusz Juskowiak \and Wioletta Róžańska",  
  title = "{Road to solving quadratic assignment problem using Physarum Machines}",  
  school = "Pozna{\n} University of Technology",  
  address = "Pozna{\n}, Poland",  
  year = "2016",  
}
```