شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

بسم الله الرحمن الرحيم

HANAA ALY

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

HANAA ALY

شبكة المعلومات الجامعية

التوثيق الإلكتروني والميكروفيلم

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأقراص المدمجة قد أعدت دون أية تغيرات

يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار

HANAA ALY

Ain Shams University

Faculty of Engineering

Architectural Engineering Department

The Implementation of Swarm Intelligence in Architectural Design

A Thesis submitted in partial fulfillment of the requirements of the degree of Master of Science in Architectural Engineering (Architecture Engineering)

By

Hager Magdy

Bachelor of Science In Architectural Engineering

(Architecture Engineering)

Faculty of Engineering, Ain Shams University, 2016

Supervised by

Prof. Hazem Talaat El Daly

Associate Prof. Amal Kamal

Cairo - (2021)

Ain Shams University
Faculty of Engineering
Architectural Engineering Department

Name: Hager Magdy Ismail

Thesis Title: The implementation of Swarm Intelligence in Architectural Design

Degree: Master of Science Degree in Architectural Engineering

The Jury Committee:	**Signature**
Prof. Ayman Hassan Ahmed Department of Architecture, Faculty of Engineering, Cairo University.	
Prof. Samir Sadek Hossny Department of Architecture, Faculty of Engineering, Ain Shams University.	
Prof. Hazem Talaat El daly Department of Architecture, Faculty of Engineering, Ain Shams University (Supervisor).	

Thesis Defense Date: 11 / 03 / 2021

Post Graduate Studies:

Approval Stamp	Faculty Council Approval
..... /..... / ……	..... /..... / ……
The Thesis was approved on	University Council Approval
..... /..... / ……	..... /..... / ……

Statement

This thesis is submitted as a partial fulfillment of Master of Science in Architectural Engineering , Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Student Name

Hager Magdy

Signature

.....

Researcher Data

Name	: Hager Magdy
Date of birth	: 11/7/1993
Place of birth	: Cairo, Egypt
Last academic degree	: B.Sc.
Field of specialization	: Architectural Engineering
University issued the degree	: Ain Shams University
Date of issued degree	: 2016
Current job	: Demonstrator

Abstract

Swarm intelligence is widely applicable in many fields. Scientists from different fields analyzed swarm intelligence behavior and applied it in the digital world through a mathematical model. This model consists of three main rules, which are separation, alignment, and cohesion.

Architects found potentials in swarm intelligence, so they applied it in architecture to go beyond common architectural designs. Different algorithms are integrated with swarm mathematical model to apply them in architectural design. These algorithms are swarm viz, metaball, and boids.

Through four chapters, a framework for applying swarm intelligence in architectural design is created. In chapter one, swarm intelligence behavior, swarm natural models, and swarm mathematical model are defined. In chapter two, the main swarm algorithms are represented and analyzed.

In chapter three, several swarm applications are analyzed to extract their procedures for applying Swarm Intelligence. In chapter four, frameworks for applying swarm intelligence in architectural design are created.

This research concludes with applying swarm intelligence framework in architecture.

Keywords: Swarm Intelligence, Algorithms, Architectural design.

Definitions

- **Swarm**: A group of similar members (Keerthi et al., 2015).
- **Swarm Agents:** Swarm members that have the same characteristics (Keerthi et al., 2015).
- **Swarm Intelligence Behavior**: A set of similar singular agents that interact with each other and the environment through a comprehensive behavior (Keerthi et al., 2015).
- **Seek Points**: Attraction or repulsion points (Reynolds, 1987).
- **Optimization**: Finding the most efficient solution for any problem or situation in the least time (Kulkarni et al., 2017).
- **Ant Colony Optimization**: A computational formula that searches for the optimal path based on ants behavior (Keerthi et al., 2015).
- **Bee Colony Optimization**: A computational formula that finds the optimum solutions for problems based on bees behavior (Keerthi et al., 2015).
- **Flocks:** Group of birds that interact with each other and emerge flocking behavior (Miranda Carranza, 2000).
  Particle Swarm Optimization: A computational method which is based on birds behavior and seeks to perform functions better (Keerthi et al., 2015).
- **Algorithm**: A computational formula with several steps that seeks to find a solution for a specific problem (Terzidis, 2006).
- **Swarm Viz**: A simulation system for Swarm intelligence, which provides information about swarm agents and their behavior (Miner & Kasch, 2008).
- **Metaball**: A simulation system for Swarm intelligence that simulates swarm agents as blobs, and provides information about swarm agents and their behavior (Kommareddy et al., 2017).
- **Boids**: A simulation System for swarm intelligence. It is based on birds' flocking behavior, and provides information about swarm agents and their behavior (Chen, 2015).

- **Superposed potential field network**: The potential field of space consists of multiple points charges based on electric potentials' principles (Kou et al., 2013).
- **Automation**: Involving machines with human functions to reorganize the work process (Geralde et al., 2017).
- **Voronoi**: A computational formula that divides the space into cells. These cells are created based on several points spread according to specific data (Şahin & Hatipoğlu, 2017).
- **Sensors**: A device converts a physical signal into an electric signal (Sinha, 2017).
- **Actuators**: A device converts input data into motion (Sinha, 2017).
- **Optimization Algorithm**: A computational formal that seeks to solve a specific problem with the most efficient solution in the least time (Kuznetsov et al., 2014).
- **Grasshopper**: is a scripting environment that enables architects to create scripts without writing the actual code. It is connected with Rhinoceros software that allows users to see the script's output as two and three-dimensional geometries (Sebestyen, 2019).

Table of Contents

List of Figures