SIMULATION OF PHYSICAL FORCES FOR WET CLOTHING

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This dissertation is dedicated to my family especially my father Mr. Salim Abdullah Ali, my mother and my brother Mr. Qusay Salim Abdullah and all my friends for their endless support and encouragement.

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ABSTRACT

One of the mostly researched areas in computer graphic is wet cloth simulation. Where, there are many factors affecting cloth simulation. Among the challenges in simulating cloth is taking into consideration all these factors for example, wetting, internal and external forces. Thus, this study aims to achieve high realism wet cloth simulation, and take in consideration the forces that may affect the process of simulation. Mass Spring Model is the technique that proposed to simulate the wet cloth under the forces of wind and gravity. Initially, to produce the cloth sheet, a cloth structure is being constructed from a matrix of mass point connected by springs. Then, external and internal forces were applied on the cloth sheet. The internal forces represent the tension between the springs in forming the cloth particles. External forces are represented by wind and gravity. Next, wetting process is applied on the fabric particles. In wetting process, cloth absorbed a substantial amount of fluid which will then affect the physical properties and appearance. In the experiment, the amount of absorbed fluid is calculated using absorption equation, with increasing values of variable up to saturation level. It was observed that there are changes on cloth texture as the wetting increased. The color of cloth texture became darker with increasing wetting value. Highest concentration of texture color can be observed as the cloth reached the saturation level. Finally, wet cloth is being compared with dry cloth in terms of color, physical behavior and motion. The cloth has all the properties of wet cloth like in the real life where, it is appear heavier, darker color, appearance and physical behavior. Future work for this study suggests many prospective works especially, simulating the real interaction between the fluid and the cloth.

ABSTRAK

Salah satu bidang yang banyak dikaji dalam grafik komputer adalah simulasi objek kain. Terdapat pelbagai faktor yang mempengaruhi simulasi kain. Antara cabaran dalam simulasi kain adalah mengambil kira semua faktor seperti pembasahan, faktor dalaman dan luaran. Oleh itu, kajian ini mensasarkan untuk mencapai simulasi kain basah yang berkualiti tinggi, dengan mengambil kira daya-daya yang mampu mempengaruhi proses simulasi tersebut. Teknik "Mass Spring Model" dicadangkan untuk simulasi kain basah di bawah pengaruh daya angin dan graviti. Untuk menghasilkan helaian kain, strukur kain dibina menggunakan matriks titik-titik yang disambungkan dengan spring. Kemudian, daya dalaman dan daya luaran dikenakan pada helaian kain tersebut. Daya dalaman mewakili ketegangan di antara spring yang membentuk partikel kain. Daya luaran diwakili oleh angin dan graviti. Seterusnya, proses pembasahan dikenakan pada partikel fabrik. Dalam proses pembasahan, penyerapan cecair pada kain memberi kesan pada ciri-ciri fizikal dan rupa kain tersebut. Dalam eksperimen yang dijalankan, nilai cecair untuk diserapkan dikira menggunakan persamaan penyerapan dengan nilai pembolehubah yang bertambah secara berperingkat sehingga aras tepu. Pemerhatian menunjukkan terdapat perubahan pada tekstur kain dengan meningkatnya nilai pembasahan. Warna pada tekstur kain menjadi bertambah gelap dengan peningkatan nilai pembasahan. Warna paling gelap terlihat apabila kain tersebut mencapai nilai tepu. Akhir sekali, kain basah tersebut dibandingkan dengan kain kering dari segi warna, ciri fizikal dan pergerakan. Kain yang terhasil mempunyai ciri-ciri yang sama seperti kain basah dalam kehidupan seharian dimana beratnya akan bertambah, warna menjadi lebih gelap dan berbeza dari segi fizikal. Kajian pada masa akan datang dalam bidang ini adalah lebih luas, terutamanya simulasi antara cecair dan kain.

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CHAPTER 1

INTRODUCTION

1.1 Overview

The computer graphics application has widely used in several fields of our life such as edutainment, military, entertainment and etc. In the recent years, computer graphic acquired advance position among the others computer sciences areas. Indeed it appeared to the computer graphic society at the beginning of computer era in 1954.

First appearance of computer graphic application was in Massachusetts institute of technology; where Jay Forrester developed the first model by simulate naval aircraft. Cloth simulation as computer graphic application has strong relationship with virtual character inside virtual environment. The existing approach on cloth simulation covers underwater cloth simulation, avatar cloth simulation or even collision in cloth simulation. The interaction between fluid and cloth in real world has become a challenge for computer graphics society.

In this thesis, we propose new techniques on wet cloth simulation to simulate the interaction between cloth and fluid during physical interaction inside virtual environment. We are focusing our work to study the properties of wet cloth and fluid that can change the behavior of cloth when they interact with wind or even gravity. Whereas, the wet cloth is affect the weight and softness of the cloth appearance and behavior. These changes are very important in representing in realistic simulation.

Most of the previous studies which used to simulate cloth under fluid influence focused on immerse the cloth completely under the fluid. In our approach we want to perceive how to simulate cloth under the impact of the fluid partially such as, cloth under rainy situation, wind and gravity interaction, etc.

In our work we are going to demonstrate the nature of the wet cloth that will contribute to several new ideas, such as walking under simulated rain or fall of fluid on the part of the fabric.

1.2 Problem Background

Cloth is one of the normal human life requirements. To simulate cloth we have to know what the components which form the fabric are. The components of the cloth are core element to describe the structure. Cloth simulation under effect of fluid still needs much attention in particular on how want produce intensive and high realistic simulation.

Keckeisen *et al.* (2003) described a Virtual Reality application that enables the user to interactively select garment patterns and place them around a 3D body using 6DOF input devices. Salazar *et al.* (2010) were suggested several cloth simulation issues. First of them was reduce the number of iterations required for collision treatment through AABB hierarchies. As cloth modeling in this form as triangular meshes composed of particles and springs, this structure of data in hierarchical form was appointed in arrange to reduce the intersection tests numbers at primitives' levels. The other issue is quantitative analysis the Computational burden for application of cloth simulation that employs approach of multi-processor on a multi-threaded CPU and on an emerging multi-core GPU-CUDA architecture. The architecture of multi-processor GPU-CUDA enables high-performance since recent GPU models offer extremely high floating-point arithmetic throughput.

Huber (2011) presented a way to simulate the cloth and the fluid that also handles fluid diffusion across absorbent textiles. Based on the cloth simulation engine, he combined the state of the art- finite element with a smoothed particle hydrodynamic (SPH) fluid simulation. He explained the possibility interaction between the fluid and textile. To make model for fluid transformation across wet cloth, Huber uses Fick's law of translation diffusion.

Fick laws equation used to compute the diffusion states; it's described as very fast discrete cellular automation. Decaudin *et al.* (2006) proposed producing virtual cloth depending completely on geometric method. The resulted fabric consisted of developed faces sheets that envelop around a mannequin normal method constructing optically bends. Furthermore, this system supply stitching models, which possible to use in deformation-free weave designing and for sewing of actual life identical to the planned clothes.

Mongus *et al.*(2011) proposed a road to obtain proper behavior of computer simulated textiles (e.g. silk, wool, cotton) the physical particularities disfigures when enabled to hang under its own weight, and is usually measured using a drape meter. Cloth and fluid simulation represent one of the most important and effective aim in computer graphic world. Where recent years has a large advance in simulate wet cloth, however the majority of this studies focused on the underwater cloth simulation. Chen *et al.*(2012) produced one of the most important approaches to simulate the cloth under wet influence. In this technique they are simulated wet garb for virtual human with realistic crease and bends. The unique characteristic of this work is the wrinkle and friction pattern. In our work, we present method to illustrate the behavior of cloth when it is been under the impact of external effects such as wet, gravity, and wind.

1.3 Problem Statement

Simulation of wet cloth has long been an objective in computer graphics areas. How to simulate a soaked garment, especially how to simulate a garment influenced by the forces of wind and gravity. Although latest years significant researches on wet cloth simulation have be prepared, the earlier work has focused on underwater cloth such as (Ozgen *et al.*,2010), saturation models (Huber, 2011) , and porous flow passing through cloth as in the work of (Lenaerts *et al.,* 2008). Yet the most familiar scenarios within animation are often simply a wet cloth. Based on the discussion as stated on problem background, there is an opportunity to enhance the cloth simulation by adding fluid to the cloth like wet cloth simulation. The main research question:

(How to create wet cloth simulation based on gravity and wind effects?)

1. Why computer Graphics need wet cloth simulation?
2. What kind of technique that suitable for simulating the influence of fluid to the cloth
3. How we can calculate physic effect of wind and gravity to the normal and wet cloth?

1.4 Aim of Study

The aim of this study is to create a new technique for cloth simulation with the effect of external forces: wind and gravity.

1.5 Research Objective

1. To produce a new method for simulating wet cloth with the considering of the effect of wind and gravity.
2. To develop a prototype for the proposed technique.

1.6 Scope of Study

This research technique is based on mass-spring systems that are still common for cloth simulation for its ability to reflect the fabrics physical properties and achieve better representation for cloth behavior. The research will study this behavior of wet clothes when it exposed to external forces, with taking into consideration the following conditions:

1. The fluid that use in this research is water
2. The external forces considered are wind and gravity
3. Mass spring model will be used to simulate cloth deformation
3. Textile mass represented as triangles
4. Cotton will be used as the basis for calculating the amount of water absorption
5. Microsoft visual studio version 2006.

1.7 Significant of study

The interaction between fluid and cloth still not explored so well, on the other hand the effect of wet cloth simulation is needed to simulate realistic physic behavior on game or 3D movies. Therefore, this research result is believed to bring great benefit to computer graphics society.

1.8 Thesis organization

This thesis is organized into five chapters. Chapter one, presents an introduction and overview of computer graphics and cloth simulation. It also includes the objectives and scope of the study. Literature review on cloth modeling and simulation explained in Chapter two. In Chapter three, the research methodology including research procedure and design is discussed. Chapter four explain in details the implementation phases and shows the research results and the evaluation. In chapter five the conclusion and the future work discussed in details.

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