Abstract. A new technique for modelling clothing is described in which the
cloth layer is closely associated with the shape of the underlying flesh layer. The
position of fold lines are determined on the basis of the distances between the
layers. Folds are generated along the fold lines using a modified sinusoidal
function. In contrast with techniques which are based on the physical properties
of the material, the technique is fast and yet produces visually acceptable
results. The technique has been incorporated within the GEOFF interactive
editor which allows the user considerable control over fold generation.

1 Introduction

Realistic display of cloth is important in the modelling of animated figures. This has
been an active subject of research in computer graphics since the 80s and a growth in
interest has been evident in recent times. Many models of cloth have been developed
which produce good results. However, these models are not widely used in computer
animation, due to the fact that many require large amounts of computation. In
particular there is a requirement to model the shape of a garment when worn by a
human. The present paper takes a sleeve worn on an arm as an example, but the
method is applicable to all parts of a garment.

A new geometrical model is presented in which the sleeve and the arm on which
it is worn are represented as a connected layered structure. The sleeve and arm are
thereby closely integrated within the model. The main goal has been to develop a
technique for generating folds in the cloth requiring minimal computational power.
There is an emphasis on the production of visually acceptable results, rather than on
solutions based on complex physical modelling. Moreover, previous techniques have
not always provided the user with adequate provision to influence the results;
accordingly an interactive editor has been incorporated to allow users to make
adjustments to the results.

2 Related Work

The modelling of cloth has been categorised into three types: the geometrical
approach, the physical approach and the hybrid approach. In the geometrical
approaches, the models are based solely on geometry considerations. Curve fitting
technique is used in [24] and [9] uses surface fitting technique.
In the physical approach, the physical properties of the cloth are used, which typically include the elasticity, strain constant and density. Energy minimisation is used in [8,16] to predict the garment shapes. A deformable model [20,21] is used by Thalmann's research team [5,12,14,15,25,26,27]. The concept of a particle system [17] is used in [3,4] to model cloth. Li et al. [13] have simulated a cloth sample in an air flow using aerodynamic theory. Aono [2] utilised the equilibrium equation of elasticity theory and D'Alembert's principle to simulate wrinkles in his model.

The physical approach requires extensive numerical processing and the time required to yield a result is greater than that of the geometrical approach. The hybrid approaches [7,11,18,19,22] are the combinations of geometrical and physical techniques.

3 The Model

3.1 A New Layered Structure

Most of the previous work has treated the cloth and the underlying object as separate entities, with the subsequent collision detection requiring considerable computational time. A layered concept has already been used successfully in many areas [6,10,23]. In this paper, we propose a new layered structure to facilitate the simulation of cloth.

The structure used in the method presented here is shown in Fig. 1. The cloth layer and flesh layer are represented by two hollow polygonal cylinders. The flesh layer surrounds the skeleton which is here represented by a thin rod. The shapes of the cylinders are defined by cross sections which can assume elliptical form, the eccentricity of which is under user control. In the examples to be described, cross sections which are initially circular have been employed for simplicity, but without loss of generality. The shape of a cross section is specified by vertices around its circumference. The two layers have identical numbers of vertices and for each vertex on one cylinder there is a matching vertex on the other. The structure shown in Fig. 1 can be taken to represent a section of an arm or leg.

![Fig. 1. Layered structure.](image)

In Fig. 2, the cloth and grid layer can be represented as a 2D rectangular grid. The vertices on the grid can therefore be easily accessed as a 2D array in the C language.