Reconstruction of 3D Human Movement Using Inverse Analysis

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Abstract

A system which reconstructs 3D human movement from a stream of 2D input images is developed. The system finds the 3D shape and motion of the human body by fitting a simple skeleton model to the markers found in the 2D image. The fitting is done using a nonlinear optimization approach. This optimization is essentially difficult because depth information can not be obtained from 2D image. In order to overcome this problem, inverse analysis technique which takes account of the following four kinds of a priori information are applied: 1 Human body can be exhibited by versatile skeleton model. 2 Joint angles have their limits. 3 Human motion is smooth. 4 Human keeps one's balance in slow motion. We reconstructed human movement from a real video images by this method in order to demonstrate its applicability.

1 Introduction

The human body motion is an "object" that can assume a great variety of complex postures. 3D reconstruction of these postures poses a challenging vision problem whose solution has a great practical interest. For instance, in the field of computer interface, computer animation, and virtual reality, a motion tracking is an indispensable technology. Various methods have been developed for this purpose. Among these methods, the video based systems have advantages because of the economical aspects and the non-contact measurement. [1] [2] [3] [4]

In this paper, the system which reconstructs 3D human movement from a stream of the 2D input images (see Fig.1) was developed. This problem is essentially ill-conditioned because depth information can not be obtained from 2D images.

To determine the final feasible body structures a priori information of human motion, e.g. physical and motion constraints were implemented in the inverse analysis.

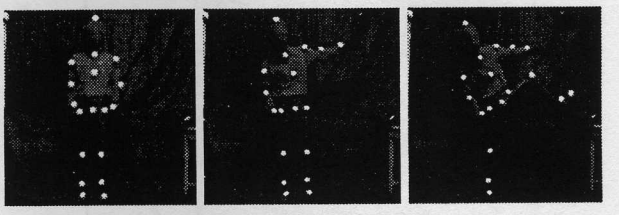

Figure 1: Sample of original Images

2 Reconstruction Procedure Using Inverse Analysis

2.1 Human body model

Since our system uses 2D images as inputs, the depth information is limited. In order to overcome this shortage of the depth information, we introduced 3D human model as a priori information.

Actual human body has over 80 degree of freedoms. For simplicity, our human body model consists of 10 major joints and its degree of freedom is 34. This 34 parameters are denoted as a 34 dimensional posture vector $\boldsymbol{\theta}_t$, where the subscript t is a time.

Figure 2 shows our human model. Each joint has its own degree of freedom as indicated in figure 2, and each size of body segment is given.

Using direct kinematics, locations of all markers can be calculated in 3D space from the posture vector $\boldsymbol{\theta}_t$. Applying a knowledge of computer graphics analysis, 2D coordinates of markers on screen $\boldsymbol{g}(\boldsymbol{\theta}_t)$ can be obtained easily[5].

2.2 Improvement of accuracy by singular value decomposition

Let $\bar{\boldsymbol{g}}_t$ be the 2D coordinates of markers in source image at t. Therefore, the problem considered in this paper is to find posture vector $\boldsymbol{\theta}_t$ for each t by solving the following non-linear equation.

$$\bar{\boldsymbol{g}}_t = \boldsymbol{g}(\boldsymbol{\theta}_t) \quad (1)$$