# Chapter 1

# Introduction

## 1.1 A Brief Overview of Computer Animation

At first computers were used to assist in the production of traditional two-dimensional animation sequences aiding such tedious tasks as editing and painting drawings [Catm78, Calv83, Bend94]. The computer acted primarily as a drawing pad and storage device to speedup the existing manual process. Now computers can produce impressive three-dimensional animations as in Lasserter's film *Tin Toy* [Lass87, Bend94]. However, achievements in generating animated models of human figures are not so impressive, because there are many difficulties in making realistic models of articulated bodies with skin and hair [Calv91b], as well as simulating their motion [Badl87].

One of the most challenging tasks is that of producing animated models which exhibit human behaviour because of the diversity of expressiveness and skills innate to the human being [Zelt82, Calv88, Sun93]. In a simple case, the body can be represented as an articulated structure with 20 segments up to several hundreds, each with varying degrees of freedom. The coordinated motion of the limbs is far from easy but is even more complex when motions of more than one model are involved. Nevertheless, a lifelike human animation sequence has been achieved, though at high cost [Thal82, Thal86]. There is a potential demand for such models in such diverse areas as choreography, education, robotics, advertising, simulation in general, etc. Computer animation has also benefited from research in some of these areas. For example, the motion of robotic arms has been simulated using mathematical equations [Paul81] developed for computer animation to calculate the positions of an articulated chain of bones in a limb as the hand reaches for a given point [Gira85, Gira87].

Computing power currently available imposes a restriction on the quality of 3-D animation of human figures in real-time. However, it is possible to generate animations of *wire frame* models which can be rendered after a satisfactory sequence has been obtained. High quality rendering may not always be required. For example, a choreographer can use simple models to explain or discuss dance steps with the cast [Calv86b]. Simple animations can also be used to design elaborate filming strategies, by experimenting with the positions of the cast within the scene [Calv83].

A major problem in the generation of animation sequences is the tedium of controlling the motion of each of the figures. Contemporary animation languages provide a powerful syntax to specify virtually all types of motion, however, these are difficult to use because they demand considerable skill to generate realistic motion sequences. Interactive systems offer benefits in providing the animator with a general view and immediate control in the composition of the animation. However, many reiterations are required before satisfaction is achieved. The whole process is thus labour intensive and very tedious.

As animation sequences become more elaborate in terms of the number of animated figures and the variety of behaviours they exhibit, the task of the animator becomes even more difficult to manage since the location and motion of the animated figures have mutual constraints and interactions. In such complex situations, it is easy to overlook the behaviour of a particular figure and many corrections may be necessary.

During the last decade progress has been made by endowing the models with the capability to control their own detailed motion in the field which has become identified as *behavioural animation*, in which a great deal of the work is undertaken by the animation system.

## 1.2 Motivation

A major problem in computer animation is the amount of work required to position the objects at each step of an animation sequence. This problem is extreme in the case of human figure animation particularly when several figures are required to move coherently in an environment. The work reported here is directed at the reduction of the work load of the animator, enabling the animation to proceed with a minimum of intervention. Animators are provided with a framework that allows them to experiment and develop new scenarios without excessive labour. Thus, the animator is able to concentrate on the creative aspects without the distraction of the low-level chores.

Our approach is concerned with behavioural animation in which the animated elements have autonomous motion and can react to the changes in the environment. The animator specifies his overall requirements using a high-level script and also supplies knowledge about the characteristic behaviour of the figures. During run-time, the changes in the environment together with the directions given in the script trigger the motive actions. Examples of environmental configurations are: John is standing up, Mary holds the tall-glass, the green table is occupied, etc. Examples of high-level directions from a script are: "Mary clear the counter", "John serve Mary the tall-glass", etc. Such high-level directions could also originate from the figures themselves autonomously, for example, when they observe somebody that has just entered their locality.

The concept of behavioural animation is described by Wilhelms [Wilh90] as:

> "... a means for automatic motion control in which animated objects are capable of sensing their environment and determining their motion within it according to certain rules"

Some fundamental requirements for behavioural animation have been discussed by Calvert [Calv91], in which an ideal system has been proposed with the following characteristics:

- at the highest level, the system accepts natural language as input as found in a script for a film or a play. The characters to be animated are identified and their special characteristics are described. Standard stage directions like "Bill enters stage left" as input to the system generates a feasible animation.

- at the intermediate level, the high-level input generates a detailed script. This script contains details of movements for the figures in terms such as gait and style of gesture, start time and duration of all movements. The animator can edit the script, adjusting it to what is needed.

- at the lowest level, detailed movement instructions for each limb segment as a function of time are accessible to the animator but seldom changed except for "fine tuning."

The task of specifying motion in behavioural animation shares problems with AI and robotics in areas such as path-planning, motion planning, problem-solving, and knowledge representation. As Calvert [Calv91] has pointed out, the use of expert systems, to capture the knowledge and skills of the animator is obvious, but the method of implementation is not.

In spite of all these developments in behavioural animation [Calv94, Mah94, Sun93], there remains a requirement for a language powerful enough to control elaborate behavioural animation with simple commands. These commands should be sufficiently sensitive to cause the animation to respond to changing conditions and contexts. Conventional animation languages are not flexible enough to generate solutions that resemble human behaviour to any reasonable degree [Calv86]. In the present work, we have, therefore exploited the use of techniques from AI and robotics, to build an animation framework for both planning and controlling the animation.

The goal of this present work is to create a framework for the animation of a multiplicity of autonomous robots, or humanoids, which inhabit a dynamically changing environment. These entities will be capable of interacting with each other and reacting to changes in the environment. The actions of these entities will be goal-directed so that their behaviour can be easily controlled by the animator through high-level commands called "*instructions*". The robots will possess a degree of autonomy and can react to their immediate environment in the absence of specific directions from the animator's script. Such animation instructions automatically plan a sequence of simpler goals by considering specific aspects of the environment. The task of an animator is considerably simplified because it is not necessary to specify the behaviour in detail.

## 1.3 Outline of the Thesis

An overview of computer animation is given in chapter two, with a review of previous work. In chapter three there is a short review of artificial intelligence tools and robotics which provide techniques to build a knowledge-based system to control the behaviour of animated entities. In chapter four an overview of the animation system which has been developed is given. An overview of the new animation control framework is presented in chapter five. In chapter six the main control mechanism named *instruction* is presented. In chapter seven the structure of the task control is presented together with some examples. In chapter eight the message mechanism is presented. In chapter 9 the scheduling of tasks is presented. Finally in chapter 10 conclusions are drawn and future work is proposed.