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Motion Capture and Tracking for Animation and Robotics

Bhupesha Rawat
Associate Professor, School of Computing, Graphic Era Hill University, Dehradun, Uttarakhand India 248002

Abstract: Motion capture and tracking have rapidly become crucial tools in the fields of animation and robotics since they make it possible to record and evaluate the motion of human subjects. In this paper, we provide an overview of motion capture and tracking, investigate the many methodologies and datasets that are now in use, describe the system components that are essential to motion capture and tracking for animation and robotics, and discuss the problems and opportunities that lie ahead for this particular field of research. In this article, we investigate the numerous motion capture and tracking systems that are currently on the market and highlight the advantages and disadvantages of each. In addition, we highlight the technological challenges of motion capture and tracking, as well as the ethical and privacy concerns that are related with these issues. In conclusion, we offer several proposals for further research, including the development of innovative motion capture and tracking methods, the collection of motion capture datasets that are both vaster and more diverse, and the assessment of ethical and privacy problems. This study, taken as a whole, sheds light on the present state of the art in motion capture and tracking technology, as well as its prospective applications in the next generation of animation and robotics.

Keywords: motion capture, tracking, animation, robotics, Human Interface, Processing Unit.

I. Introduction

When it comes to animation and robotics, motion capture and tracking are two crucial approaches for capturing and recreating human or object movements in a digital setting. Motion capture is the process of employing sensors and cameras to record an object's or person's movements in real time, while tracking is the process of recording an object's or person's location and movement over time. These methods see extensive application in numerous sectors, including the media, healthcare, and industry. Movements capture may be traced back to the early 20th century, when scientists first began experimenting with various methods of recording human movements. Max Fleischer created the first motion capture technique in the 1930s so he could produce cartoon characters. Although the first digital motion capture systems were developed in the 1970s, widespread adoption of the technology did not occur until the 2000s.Since then, motion capture has rapidly expanded in popularity, becoming an integral part of the animation and filmmaking process. The method has also been adopted by other industries, such as the tracking of patients' and players' motion in physical therapy and sports training.In contrast, tracking has a long history of application in a wide range of fields, including robotics, where it is used to direct the actions of autonomous robots. In sports, tracking has been used to follow players as they run drills or compete. Technology advancements in recent years have allowed for the creation of more refined motion capture and tracking systems. These systems are being used for a wide variety of tasks because to their improved accuracy and versatility. This paper's goal is to survey motion capture and tracking methods and their implementations in animation and robotics. The study will begin by examining the various motion capture and tracking methods currently in use, highlighting both their strengths and weaknesses. After that, we'll take a look at the big picture of motion capture and tracking systems and compare the various options. The paper will then discuss how motion capture and tracking are utilized in many areas of animation such as facial animation, character animation, and motion graphics. We'll also talk about the ways in which motion capture and tracking have been put to use in robotics, such as in motion planning, robot surgery, and HRI (human-robot interaction).The report concludes with a discussion of the technical difficulties, ethical and privacy considerations, and possible future advancements in the field of motion capture and tracking. A brief review of the paper's major findings and suggestions for future study will round off the piece. Motion capture and tracking are two crucial methods that have significantly influenced the development of the animation and robotics industries. They have allowed for more precise and accurate control of robotic systems and allowed animators to produce more realistic and lifelike characters. Even if other technologies improve, motion capture and tracking are expected to remain useful in a wide variety of contexts.

A. Background and history of motion capture and tracking

For a long time, computer graphics researchers have focused on improving their ability to model and animate natural occurrences for use in visual effects. With the rise of CGI in the entertainment industry, more and more lifelike depictions of water, fire, smoke, and weather are required. Understanding the physics and behavior of these natural events and creating algorithms and strategies to simulate and animate them in a virtual world are essential for creating realistic visual effects. The particle system, pioneered by William Reeves in 1983, is one of the earliest and best-known examples of natural phenomena simulation in computer graphics. To create and animate a huge number of basic entities, or "particles," a particle system can be used. Natural events like smoke, fire, and explosions can be simulated by manipulating the behavior of these particles. Particle systems and other methods for simulating and animating the workings of the natural world have been steadily refined by researchers and developers over the years. Computational fluid dynamics (CFD) simulations have become increasingly popular in recent years for the purpose of simulating natural processes in the visual effects industry. Simulations of fluids like water, smoke, and fire can be made with greater realism and accuracy thanks to computational fluid dynamics (CFD), which employs numerical methods to solve the equations governing fluid motion.

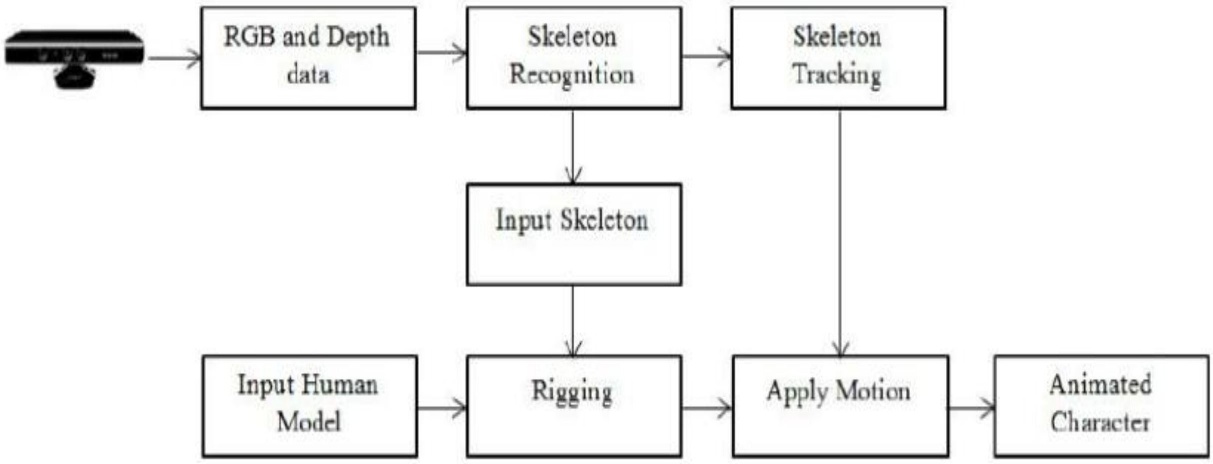

Figure 1. Basic Block Diagram for Motion capture and tracking for animation and robotics

The creation of machine learning methods for simulating natural occurrences is another major topic of study. For more realistic and precise virtual environment simulations, machine learning algorithms can be trained on vast datasets of actual natural phenomena to learn the underlying physics and behavior. Stunning visual effects that were previously impossible or prohibitive to accomplish with standard filmmaking techniques have been made available thanks to the development of natural phenomenon simulation techniques, which have had a profound impact on the film and gaming industries. The high processing cost of simulations, the difficulty of replicating complex interactions between different natural phenomena, and the need for more accurate and efficient simulation methods are only a few examples of the many obstacles and constraints still present in this subject. Generalizing, the field of studying how to represent and animate natural processes for visual effects is crucial and dynamic, with the potential to revolutionize the way we produce and consume visual media.

B. Purpose and objective of the research paper

Motivation for this study of motion capture and tracking techniques for use in animation and robotics This study's goal is to investigate the numerous ways taken in motion capture and tracking for animation and robotics. The purpose of this article is to study the most recent advancements in motion capture and tracking technology, focusing on their uses in the entertainment and manufacturing industries. The following are the questions that will hopefully be answered by the paper:

i. In the fields of animation and robotics, what are the many methods for motion capture and tracking?
ii. To what extent do current motion capture and tracking technologies succeed and where do they fall short?
iii. What are some applications of motion capture and tracking technologies in cartoons and robots?
iv. When it comes to animation and robots, where do you see motion capture and tracking go in the future?

Ultimately, this paper aims to provide a thorough overview of the current state-of-the-art in motion capture and tracking for animation and robotics, as well as to indicate potential future areas for study and development in this area. This study will help fill in some of the gaps in our understanding of motion capture and tracking, and it will be of particular interest to those in the fields of animation and robotics.

C. Motion Capture

Motion capture, sometimes referred to as mocap, is a method utilized in the fields of computer animation, robotics, and visual effects. In this method, sensors and markers are attached to the subject or object in order to capture its motions. The sensors' readings are analyzed, and the results are utilized to generate a computer simulation of the subject's motions.

i. Techniques used for motion capture

Among the many methods available for motion capture are:

To capture a subject's motion, optical motion capture uses a set of cameras and markers. Markers are attached on the subject, and their motion is tracked by cameras; the resulting data is used to generate a 3D model of the subject's motion. Sensors like accelerometers and gyroscopes are used in inertial motion capture to record the subject's motions. After attaching the sensors to the human or the object being tracked, the data is processed to generate a three-dimensional representation. To capture a subject's motion, magnetic sensors are used in magnetic motion capture. A 3D model of the subject's body is constructed after sensors are attached to various locations across the body. No markers or sensors are required for this method of motion capture, which instead relies on computer vision algorithms to precisely follow the subject's every move. The method employs a set of cameras to record the subject's motion while a set of algorithms analyses the data to construct a 3D representation of the scene.

ii. Applications of motion capture in animation and robotics

Among the many uses of motion capture technology in animation and robotics are:

In animation, motion capture is commonly utilized to give figures natural, convincing motion. The method is used to record the actions of actors and then transfer them to computer-generated characters for a more lifelike animation. For a more immersive virtual reality experience, motion capture is also employed in programs that track the user's motions. In robotics, motion capture is utilized to give robots more lifelike and organic motions. Human motion is captured using this method so that it can be programmed into robots to give them more lifelike motion.

II. III. Existing Techniques

When it comes to animation and robotics, motion capture and tracking techniques already exist in abundance. There are two primary ways to categorize these methods: optical and non-optical.

A. Instruments of Vision:

i. Marker-Based Motion Capture:

In order to capture motion, one of the most prevalent methods is marker-based motion capture. Markers are attached to the subject or object, and their motion is tracked by a camera. Typically, these markers take the form of tiny reflective spheres that bounce infrared light back to the camera. The camera then records the subject's motion while the markers are in place, and uses this information to generate a 3D computer model.

ii. Marker less Motion Capture:

Marker less motion capture eliminates the need for markers by relying on computer vision algorithms to follow the subject's every move. This method shines when tracking animal behavior or in situations where using markers would be impractical, like when operating in the great outdoors.

iii. Multi-Camera Motion Capture:

In multi-camera motion capture, numerous cameras are used to record the subject's motion from a variety of perspectives. When compared to single-camera motion capture, the results from this method are more accurate and detailed.

iv. Time-of-Flight Cameras:

Time-of-Flight Cameras: These cameras use infrared light to calculate how far away an object is from the lens. This method excels in recording the motion of swiftly moving objects.

B. Non-Optical Techniques:

i. Inertial Measurement Units (IMUs):

Small, wearable sensors called inertial measurement units (IMUs) track the acceleration and rotation of the person. These sensors allow for motion tracking without the usage of cameras or markers.

ii. Magnetic Motion Capture:

The use of magnetic sensors to track the subject's movements is at the heart of magnetic motion capture. The sensors are attached to the person or thing being tracked; a magnetic field then follows their movements.

iii. Electromyography (EMG):

Electromyography (EMG) is a method for monitoring electrical activity in the muscles of a patient. This method can be used to record the subject's muscle activity, which can be helpful in situations calling for a high degree of accuracy.

v. Pressure Sensors:

The force exerted by a subject on a surface can be determined with the use of a pressure sensor. This method is especially helpful in applications where the subject is engaging with a surface, such as a virtual reality setting, where the subject's feet and hands may be tracked.

Technique/Approach	**Description**	**Advantages**
Marker-based Motion	Involves placing markers on the subject's body or an object and using a camera to	Provides high accuracy and precision. Suitable for capturing complex

Capture	capture their movement.	movements.
Markerless Motion Capture	Uses computer vision algorithms to track the movement of the subject without the need for markers.	Does not require markers, which can be useful in applications where they are not practical. Can be used to capture the movement of animals.
Multi-Camera Motion Capture	Uses multiple cameras to capture the movement of the subject from different angles.	Provides a more detailed and accurate representation of the subject's movement than single-camera motion capture.
Inertial Measurement Units (IMUs)	Small, wearable sensors that measure the acceleration and rotation of the subject's body.	Can be used to track the subject's movement without the need for cameras or markers. Suitable for capturing movements in outdoor environments.
Magnetic Motion Capture	Uses magnetic sensors to track the movement of the subject.	Can be used to capture the movement of objects in environments where other techniques may not be practical.
Electromyography (EMG)	Involves measuring the electrical activity of the subject's muscles.	Can be used to capture the movement of the subject's muscles with high precision. Suitable for applications where high precision is required.
Pressure Sensors	Used to measure the pressure applied to a surface by the subject.	Can be used to capture the movement of the subject's feet or hands, and can be particularly useful in applications where the subject is interacting with a surface.

Table 1. Comparative Study of Existing Techniques

It is possible to combine these methods in a number of different ways to develop hybrid motion capture systems that are suited to a variety of applications. For instance, a system might utilise optical sensors in addition to inertial sensors in order to record the movement of the subject with a high level of accuracy and precision.

III. Proposed System Components

Motion capture and tracking systems for animation and robotics can be broken down into three primary parts: hardware, software, and integration.

A. Hardware Components:

Optical, inertial, and magnetic motion capture devices are examples of hardware components.

Cameras, accelerometers, and gyroscopes are all examples of sensors. Instruments used for setting standards (including calibration frames and software)Tools used in computing (personal computers, servers, embedded systems, etc.)The physical components of a network (cables, wireless access points, etc.)The key hardware components for recording motion data are motion capture devices and sensors. High-end optical setups with several cameras sit beside low-cost inertial systems consisting of wearable sensors. Tools for calibration are used to guarantee exact data collection. Data processing and communication between the various parts of the system require computing machines and network infrastructure.

B. Software Components:

Animation capture programs (like Vicon Nexus and Opti TrackMotive) Applications like MATLAB and Python that can process dataSoftware for making cartoons (like Autodesk Maya or Unity).Robot operating systems (ROS) and robotics system toolboxes (e.g., MATLAB)To set up the motion capture hardware and record motion data, software is used. The motion data is processed and analyses with data processing tools. Animated sequences can be developed and revised with the use of animation software. Motion data is utilized by robot control software to direct the robot's motions.

C. Integration Components:

Tools for integrating: programs that translate between different file typesSoftware for receiving data in real time (like VRPN or OSC)Instrumentation softwareIn order to integrate with various software and hardware components, it is often essential to translate motion data from one format to another. Motion data is streamed in real time to other software or hardware components using real-time data streaming techniques. For the purpose of bringing together disparate pieces of software and hardware, middleware serves as a standard interface.Accurate and dependable motion data collection, processing, and integration are essential to the success of animation and robot control applications, which is why these systems are so important.

IV. Existing Datasets

Object or person motion can be tracked in real-time with the help of cameras, sensors, and algorithms found in motion capture (Mocap) systems. The animation and film industries frequently employ such techniques to give their characters lifelike motion. This information is then used to give life to digital characters in animation.

Dataset	Description	Applications
CMU Motion Capture Database	A large motion capture database containing a wide variety of motions, including dance, sports, and everyday activities.	Animation, robotics, human-computer interaction, and biomechanical research.
HumanEva	A dataset of human activities captured using multiple cameras and a motion capture system.	Human activity recognition, action recognition, and motion analysis.
KIT Motion-Language Dataset	A dataset containing video clips of human motions and natural language descriptions of those motions.	Human-robot interaction, human-computer interaction, and natural language processing.
3D MNIST Handwritten Digits	A dataset of 3D hand movements captured using a Leap Motion controller.	Gesture recognition, human-computer interaction, and robotics.
MuJoCo Humanoid Dataset	A dataset of human motions captured using a motion capture system and simulated in the MuJoCo physics engine.	Robotics, animation, and motion analysis.
MPII Human Pose Dataset	A dataset of human poses captured using a multi-camera setup.	Human pose estimation, action recognition, and gesture recognition.

AIST++	A dataset of human motions captured using a motion capture system and a depth camera.	Robotics, human-robot interaction, and motion analysis.

Table 2. List of Data Set Can be used for Simulation of Research Work

In contrast, tracking systems monitor the whereabouts and activities of things and people. Accelerometers, gyroscopes, and magnetometers are only few of the sensors utilized by these systems. They are commonly implemented in real-time tracking systems in robotics and augmented reality.

V. Challenges and Future Directions

Like any other technology, motion capture and tracking systems have their own set of advantages and disadvantages. Here, we'll go through some of the technical obstacles, ethical considerations, and possible future developments in the realm of motion capture and tracking.

A. Technical challenges in motion capture and tracking

Achieving precise and trustworthy data in real time is one of the key technical hurdles in motion capture and tracking. In order to accomplish this, sophisticated algorithms and sensors that can collect and analyse data rapidly and precisely are needed. The problem of occlusion arises when data is insufficient or erroneous because of parts of the body or objects being out of view. Furthermore, it might be challenging to effectively capture various forms of motion, such as quick motions or complex gestures.

B. Ethical and privacy concerns related to motion capture and tracking

Several moral and privacy issues have been raised in connection with motion capture and tracking technologies. The risk for data misuse or unauthorized access to sensitive information is a major cause for alarm. Personal biometric data or sensitive mobility data could fall under this category, as both can be used to identify and track persons. Questions of privacy and individual rights are also raised by the possibility for surveillance applications of motion capture and tracking.

C. Future directions and potential developments in motion capture and tracking

Despite current obstacles and restrictions, motion capture and tracking systems have room to grow and improve soon. One focus is on enhancing data accuracy and reliability, especially in dynamic or complicated settings. Better data collection and processing may necessitate the creation of novel sensors or algorithms. The accessibility and usefulness of motion capture and tracking technologies are also being worked on to make them more widely applicable. Motion capture and tracking solutions that incorporate machine learning and AI are also becoming increasingly popular. These developments have the potential to facilitate more complex analysis and manipulation of motion data, while also increasing its accuracy and reliability. Concerns have been raised concerning the possibility of unethical or invasive applications of these technologies, underlining the need for ethical rules and monitoring in the creation and usage of motion capture and tracking systems. Motion capture and tracking systems have advanced greatly in recent years, opening up novel avenues for exploration in the fields of animation, robotics, and virtual reality. However, there are still substantial obstacles and restrictions, as well as ethical and privacy concerns, that need to be addressed. More work on motion capture and tracking technologies could open the door to even more cutting-edge uses in the not-too-distant future.

VI. Conclusion

In conclusion, motion capture and tracking have developed into crucial resources for the fields of animation and robotics, enabling the study of human motion for the purpose of controlling computer-generated characters. In this study, we have introduced the topic of motion capture and tracking, reviewed some relevant literature, and detailed some of the key methodologies, datasets, system components, and issues in this area as it relates to animation and robotics.A few of the study's most salient conclusions concern the importance of precise data capture and processing for effective animation and robot control applications, the relative merits of various motion capture and tracking systems, and the scope for future advancements in this field.This study has important ramifications for the fields of animation and robotics, where motion capture and tracking remain indispensable tools for producing high-quality animated content and pioneering innovative uses of robots. The use of motion data in animation can result in more realistic and emotive characters, while the combination of motion capture and tracking technology with robotics has the potential to generate more responsive and intelligent robots.It is suggested that researchers investigate the ethical and privacy aspects of motion capture and tracking technology, develop novel motion capture and tracking techniques and systems, and build larger and more diversified motion capture datasets.The findings of this study shed light on the state of the art of motion capture and tracking, as well as its potential for future advancements in the domains of animation and robotics

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