

AMASS2 Introduction

Overview

Optically based three-dimensional (3D) motion capture systems utilize multiple cameras to simultaneously record image data from different perspectives and then process the data to yield three-dimensional information. In the current context we restrict ourselves to imaging and extracting 3D information on “points”, and do not include surfaces or volumes unless they may be constructed from a multitude of points. Physically every point has a finite extent and is usually defined by the location of a marker (or target). Typically markers are spherical for optimal accuracy but that is not a requirement, as for example with systems that use active markers (LEDs).

AMASS (**AD**Tech **M**otion **A**nalysis **S**oftware **S**ystem) is a software package for deriving the three-dimensional (3D) locations of passive targets (unidentified markers) imaged by any number of video cameras, and writing the identified marker data to files using the [C3D file format](#). Input data are the marker centroids expressed in each camera’s image coordinate system, and a small number of parameters. The complete AMASS software and documentation is available as a free download for evaluation purposes, however a calibration wand must be purchased if you wish to use AMASS within your application.

Features of AMASS

- Low cost
- Simple to learn and use
- High accuracy
- Single data capture and computation for calibration
- Small number of calibration and tracking parameters to manage
- Very tolerant of extraneous light sources and camera strobes
- Accepts raw camera data from other motion capture systems
- Incorporates a very general link model for assisted marker labeling
- Free download of complete software for evaluation purposes
- A calibration wand is included

About the developer

Andrew Dainis received his Ph.D. in Mathematical Physics from the University of Adelaide, South Australia, and later completed an M.A. in the Department of Physical Education of the University of North Carolina, Chapel Hill. In 1982 he left his Associate Professor’s position at the University of Maryland where he taught and carried out research in biomechanics, to develop software and consult with the Biomechanics Laboratory at the National Institutes of Health.

Since that time Dr. Dainis has developed and implemented a number of innovations in 3D motion measurements, many of which are in routine use today. The use of grids for camera lens distortion corrections, automated 3D reconstruction from unidentified camera image data, and the use of residuals as a measure of data reliability are just some examples. In 1988 he designed the C3D file format which, thanks to the efforts of Edi Cramp and the <http://www.c3d.org> website developed and

maintained by him, has become a widespread means of exchanging biomechanical data. In 1995 Dr. Dainis developed the first wand calibration, a technique that has now become the standard for most motion capture systems.

His calibration and 3D tracking software has at one time or another been at the core of a significant number of commercial motion capture systems such as Oxford Metrics Ltd. (Vicon), Selcom (Selspot), Qualisys (MacReflex, Qualisys), BTS (Elite), Peak Performance (Peak Motus), Advanced Realtime Tracking, and Innovision.

Some years ago Dr. Dainis began development of the “ultimate” software package for video based 3D motion measurements, one that is general, requires the theoretically minimum user input, and provided the maximum accuracy possible from video hardware. The result is the AMASS software described in this document.

A little history

The original AMASS was released in 1988 and presented novel solutions to issues such as camera lens distortions, camera system calibration, image data reduction, and integrated 2D and 3D marker tracking. Since that time computer, camera, and software technology has grown at a rapid pace to the point where an inexpensive desktop computer and off-the-shelf cameras can easily collect and process data from many cameras, and create extremely large data files.

Unfortunately the ease-of-use of 3D measurement systems has not kept pace with hardware improvements, with the consequence that many commercial systems still have a steep learning curve and often require dedicated professionals for their effective operation. The reason for this is twofold:

1. The systems are inherently complex, involving camera and computer technology, optics, 3D geometry, and individual application requirements, and it is very difficult to provide an integrated system that has the intelligence to reduce this complexity down to a point where the system can be easily operated by a novice user.
2. Many currently available software implementations are based on legacy software that is very difficult to modify without starting from scratch. An additional factor is that many modern software techniques (e.g. wand calibrations) are not in the public domain because they have been developed for proprietary use in commercial packages.

Purpose

This completely new version of AMASS aims to provide the easiest-to-use software package that is theoretically possible, and much effort has gone into reducing the need for detailed user input, and guiding the user throughout the process. An equal emphasis has been placed on the accuracy of the camera and system calibrations by use of a new type of wand which ensures optimal accuracy, and facilitates reliable 3D reconstruction and tracking of markers. As such, it is expected that the package will find wide application in research laboratories, clinics, animation studios, and many educational settings.

Components

This section briefly introduces some key aspects of AMASS.

AMASS shell

AMASS consists of a number of closely integrated programs accessed from the main [AMASS shell](#) program, and one or more calibration wands, supplied through [C-Motion Inc.](#), that must be used to calibrate the cameras and hardware system before 3D data can be generated. The following figure illustrates the connections between the various software components.



AMASS uses *.cen* (centroid) files as input to the **Calibrate** and **Track** components. *.cen* files are binary files that contain the marker centers for every frame for every camera in the system. If the camera data come from a system other than C-Motion **Capture2D** they must be converted to *.cen* file format before use. AMASS provides conversion capabilities for selected systems.

Once a calibration has been performed on a suitable *.cen* file (containing data with suitable wand motions), the resulting calibration (*.cal*) file is available to be used for reconstruction and tracking of subsequent data files. The **Track** program takes a *.cen* file, a *.cal* file, and some parameters specified in the Project file, and generates unidentified 3D trajectories which are written to an intermediate segment (*.seg*) file. The **Identify** program is then used to graphically display the segment data and allows the user to associate marker labels with each segment. When all of the required labeling has been carried out the user can write the final results to a *.c3d* file.

Projects

A [project](#) is a data set that contains all of the information that AMASS needs to process camera data for a particular application. In particular it stores the processing parameters required by the various components, and the names of the data files' source and destination folders. All data for individual projects are stored in project (*.prj*) files, providing a very versatile environment for managing data. Projects can be easily created, loaded, modified, and saved.

Parameters

Each program component requires a small number of user supplied parameters that are stored in the Project file. These parameters can be readily viewed and modified from the AMASS shell, and are automatically saved to the Project file.

Calibration wand

The [AMASS wand](#) is a carefully manufactured calibration tool that guarantees the accuracy of every completed calibration, and results in the most reliable and accurate 3D data from the measurement system. It should be emphasized that wands acquired from other sources will not work with the

AMASS software because during the calibration each wand is uniquely identified by the software. This facility makes it unnecessary for the user to supply any data pertaining to the wand, and ensures that the wand meets required standards for construction and accuracy.

Reference markers

Static [reference markers](#) may be placed in the measurement volume during calibration data capture to define the **Global Coordinate System (GCS)** in which all three-dimensional (3D) measurements will be expressed.

Camera data requirements

AMASS accepts camera data via *.cen* files. A *.cen* file is binary file designed to efficiently hold data collected from all cameras for a single trial. It may also store camera parameter data, but as a minimum it will contain the (x,y) image coordinates of marker centroids from every frame and every camera in the system. In the current implementation it is assumed that all cameras are synchronized, i.e. each frame for all cameras was exposed at the same instant in time. Typically a marker centroid is a single point in the image that is deduced to be the best estimate of center of the marker's image. Currently AMASS does not require or use any other marker image data such as size, circularity, etc.

The C-Motion **Capture2D** program outputs *.cen* files which can be utilized directly by AMASS. Raw camera data files created by other motion capture systems must first be converted to *.cen* file format, and AMASS provides a single step conversion capability for selected systems.

For users wishing to generate their own *.cen* files AMASS includes a dynamic link library (dll) that can be readily implemented to write centroid data to a *.cen* file. Refer to Appendix A of the AMASS PDF documentation for details.

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Last update: **2024/07/17 15:21**

