Our Living Archaeological Heritage: A Portrayal of Mankind

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Abstract

This paper proposes a new line of investigation to be undertaken by the Universidad Politécnica de Madrid's CARPA Group (Cartografía en Patrimonio y Arqueología). Since 1996, we have been collecting a range of data related to heritage using photogrammetry and 3D scanning as well as other techniques. Furthermore, multimedia presentations have been produced and many innovative types of museum pieces have been conceived. To take up the challenge of making continuous improvements to the way in which our heritage is documented and presented, we envisage a new concept: Our Living Heritage. By this, we refer to everything which today may or may not be considered as heritage, but which in the future will surely be regarded as such, at a time when our epoch needs to be explained. Our present work provides an experimental response to ensuring the viability of efforts to capture the human form for posterity by means of surveying techniques, which overcomes the limitations of traditional techniques past (stone) and present (wax).

1 Introduction

Since ancient times human beings have tried to show their immediate reality, including their surroundings, either as art, or as description of a technique or a teaching, centering their interest on the portrayal of the human figure in movement by attempting to exaggerate its features of movement. From that prehistoric reality to the present, the portrayal of the human figure and its dynamism have been a point of study for artists, thinkers, and scientists—including archaeologists and heritage experts—using a wide diversity of materials and technical media. Through this study of human figure portrayal, a science was created: kinanthropometry, also known as cineanthropometry, which attempts to portray the human figure, static or in movement, as realistically as possible. The word "kinanthropometry" is derived from the Greek "*kinein*" which means locomotion or movement, "*anthropos*" meaning human, and, finally, "*metrein,*" meaning measurement. Carter (1982) and Ross (1988) defined it as the study of the size, proportion, maturation, form, and composition of the body, with the aim of describing physical characteristics, evaluating and portraying growth, nutrition, and the effects of training. We can consider it as a quantitative interface between morphology and physiology, or structure and function, to help interpret the dynamics of growth, exercise, nutrition, and the influence of movement on human physique.

In Esparza (1993), we find references to Tittel and Ross, who maintain that this term also serves to identify biomechanical factors, so that the body's shape and function are intimately related, and shape plays a decisive role in sports performance. This means that the capacity for physical exercise or work will be closely related to the quantity and proportion of the different tissues and segments of the human body and to the economy of management of movements. This science was born as an interdisciplinary field of scientific study (anthropologists, nutritionists, physiologists, biomechanics, and physical education teachers, among others) for the purpose of unifying criteria and methods in the study of the evaluation of man in movement. We consider that one of the foundations of biomechanics is the multidisciplinary study of the measurements of the human body, its movement, and derivations from it.

The availability of an accurate digital representation opens up several possibilities for utilization either byr experts or by ordinary people. The results of the analysis campaign on Michelangelo´s David are described in the book *Exploring David: Diagnostic Tests and State of Conservation* (Bracci et al. 2004). They explained how researchers have used the three-dimensional (3D) model to enhance their research. They report how they are using the model as a support medium to present archived restoration data, and they describe the intermediate processing phases to prepare the 3D data for different applications. In regards to this exciting opportunity to introduce the use of digital 3D models in the representations of works of art, we are presented with the challenge of acknowledging that, in his time, David was a person. Today we have the goal of representing these people. To represent them at museums, our only answer has been the use of wax; but because of the limits of wax representations, we are seeking a new methodology.

In this multidisciplinary mode, great advances have been made thanks to the interest and constancy of numerous researchers whose contributions have been to devise new methods and to perfect instruments of measurement. Thus, in recent decades, and in parallel to the evolution of modeling sciences, there has been an attempt to analyze and explain the different aspects of the human figure and its movement through different disciplines in order to propose

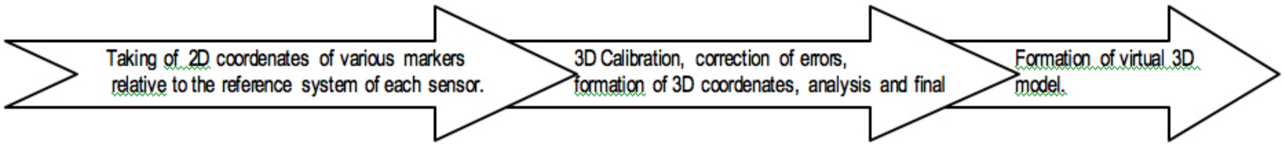

Figure 1. Steps in the taking of data by means of photogrammetric systems.

procedures for evaluating and representing the performance of people.

2 Techniques in Current Use

For more than a century, photo-instrumentation has been the technique *par excellence* applied to the analysis of human movement. Photogrammetry, as a part of photo-instrumentation, is a method by which the spatial coordinates of the points of interest (anatomical points) are calculated on the basis of the plane coordinates of the digitized points recorded simultaneously by at least two cameras (Woltring 1995). Thus, until now, the acquisition of data required prior selection, by the operator, of the points to be rendered (passive or active markers depending on the brightness and the individual capture of each one of them). The fundamental lines and the unique features had to be chosen. After thinking, selecting, measuring, and laboriously calculating the data, the element being studied could be reconstructed. It was a matter of obtaining the model by following a sequence that went "from the point to the surface" with much human intervention in the intermediate stages.

In these systems of measurement, the recordings are limited to taking the spatial position of a small number of points (markers), all on the surface of the body, whose movement proxies the movement of the segments that form the union of those points (Zatsiorski 1988; Vera 1989). Their capture represents a partial view of the reality, as it takes the information obtained by the sensors, which are limited in number, position, and processes, digitizes and models it, transforming the information contained in the image into a numerical representation that can be processed by a computer.

All this makes it necessary to carry out a long and tedious post-processing, with a high consumption of resources. Subsequently, optoelectronic systems began to be used, based on the use of television cameras able to detect the position of passive or active markers, depending on brightness, in real-time. These systems have been much used in the field of biomechanics of human movement in laboratory conditions. In the 1990s, and even today, systems such as ELITE (Elaboratore di Immagini TElevisive, Centro de Bioingeniería de Milan, 1983), VICON VX (VIdes CONverter for Biomechanics, University of Strathclycle, 1989), PRIMAS (Precision Motion Analysis System), Expert Vision HirRes 3D (High Resolution 3D Motion Analysis System), are in use, which are classified according to the sensors they employ: PSD (position Sensitive Devices), or CCD (Charge Coupled Devices, in line or in area).Through the use of these systems, using multiple cameras, the coordinates of the markers are calculated almost in real-time, which partly reduces the post-processing time. But we still have a geometrical image of the human figure, formed by a limited number of points, with the result being very partial and not clearly defined. These systems, and other similar variants, are always based on the use of passive or active markers, obtaining better results with the latter (better space-time resolution and un-simulated identification of the markers), but the use of interpolation procedures is always necessary to estimate the position of the markers at the same instant of time, which causes a loss of quality in the final results. All this leads to systematic errors produced by the distortion of the image, errors of scale, accidental errors due to incorrect positioning of the markers, errors in digitization, errors in the mathematical post-process, etc., which causes problems in the reconstruction of the coordinates in space-time and, consequently, in the portrayal of the human figure and its movement (Figure 1).

3 Cartographic Techniques as Alternatives

In parallel with these principles, cartographic techniques have evolved at great speed, permitting information to be available nearly in real-time, but their application has been limited to the representation of the earth's surface and, in some recent cases, to the cataloguing of artistic heritage. The growing use of the advances occurring in audiovisual and technological media in recent years has favored the implantation of graphics systems as essential working media in all teaching-learning processes. The use of computers as audiovisual work tools, and their calculating power, currently allows the design of models and processes with high potential for development, expression, study, and operability. Graphic representation has always been an essential complement to any type of biomechanical analysis, because the kinematic and kinetic variables obtained enable statistical studies and simulations (digital models) to be made of the behavior of the human body.

All this is currently subordinated to the method of capture, through which the variables of space and time play a decisive role in obtaining good results that can be operational within a short time. Through an examination of state-of-the-art technology, with respect to the portrayal, static and/or dynamic, of the human figure, we can observe that the most recent systems being applied are based on photo-interpretation techniques or opto-electronic systems. Both systems record the spatial position of a number of spatial markers associated with the surface of the body, whose movement supposedly reflects the movement of the segments of the body. It is thus complicated to make decisions with respect to the relationship between the markers and the anatomical characteristics of the structure underlying and associated with them. In the development of science, cartographic

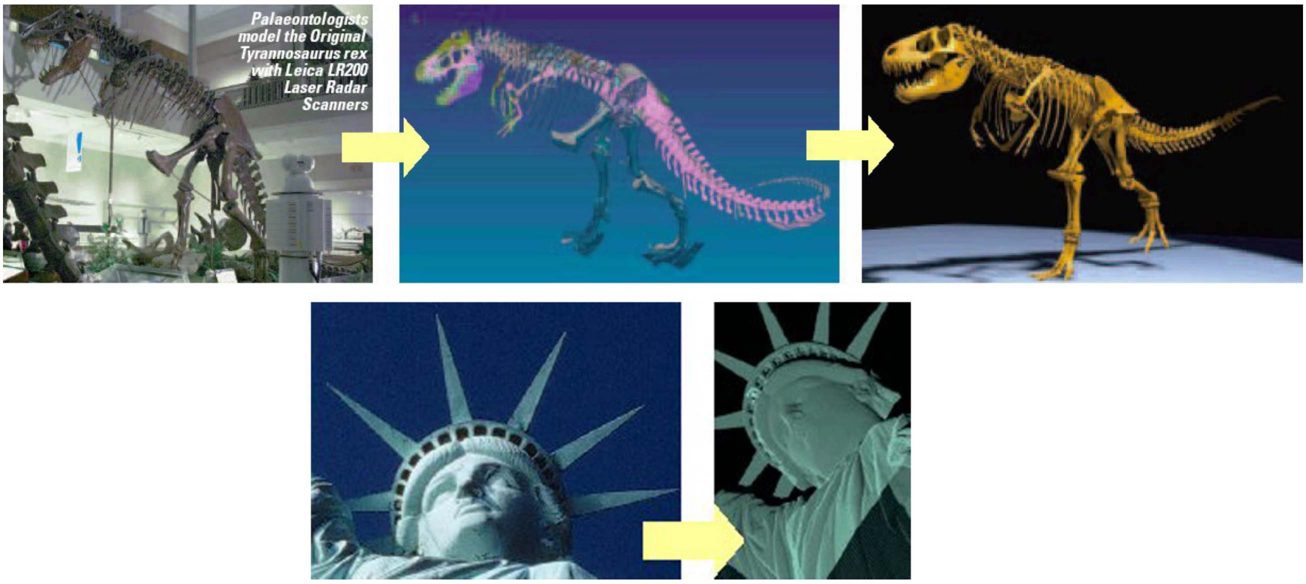

Figure 2. Examples of captures made by prism-less laser.

techniques have been traditionally linked to the study and portrayal of terrain, in any of its states or situations, obtaining digital images in two or three dimensions, which were applied in cartographic applications. But these techniques, little by little, have been changing their original monothematic conception towards a more generalist and multidisciplinary situation, as an essential support to other sciences in their studies or projects. There have been notable advances in the study and cataloguing of architectural works or in support of the analysis of deformations of materials.

The emergence of prism-less laser acquisition systems permits us to attempt the acquisition of data without prior discrimination of points (without markers). In addition, it is not necessary to put elements of point materialization in place first to facilitate the subsequent process of calculation, and the information is acquired more rapidly. Thus, the subsequent calculation process is minimized. With these systems, the whole of the selected area is portrayed, obtaining a continuous 2D or 3D image of the figure to be rendered, where the density of points to be taken is maximized according to the accuracy desired. This situation allows us to work on the "concept" of surface directly and, from the surfaces, analyze the singularity of the detail, as opposed to traditional systems which acquire points in order to imagine surfaces at those points.

The use of this technology will enable us to work with the human figure in real-time, as opposed to other systems that require further time-consuming computer processing. Its principal advantage is that each figure is different and with a high degree of resemblance to the real model, and the program models it in very close to real-time. This permits the human figure to be modeled individually, realistically, and operationally in time, form, and space, which makes it possible to examine in depth the elastic capacities of the biological surface materials of which the figure is composed, at different moments in time both rapidly and accurately. This technique is being used with some success in certain modeling contexts, representative examples of which are "Tyrannosaurus Rex by the Carnegie Museum of Natural History (Pittsburgh, PA)" or in the "Statue of Liberty of New York by The College of Architecture at Texas Tech University in cooperation with the Historic American Buildings Survey and the National Park Service" (Figure 2).

The use of these systems has also resulted in the so-called "reverse engineering or retro-engineering," consisting in the duplication of parts, components, or sets without the help of plans and/or documentation, by obtaining 3D CAD models of an existing object in order to reproduce it as exactly as possible later. The new technologies permit us to describe, analyze, evaluate, and model (statically and kinetically) the human figure and its movement (kinematic analysis) in order to resolve and optimize questions of new cultural heritage analysis, by means of representations of the model, with a precision and within a time frame that was formerly unthinkable (see Figure 3).

The "flight time" (there-and-back cycle) for each point on the surface of the object is measured by means of pulsed laser beam systems. For this purpose, there is a timing device with a resolution of 1 pico-second, which permits

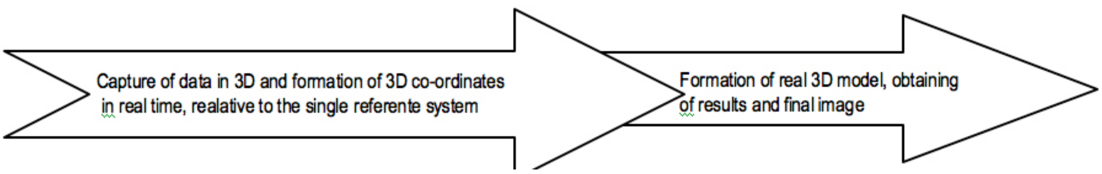

Figure 3. Steps in the capture of data with prism-less laser.

beams of less than 6 mm in diameter to be maintained at a distance of 50 m from the object. In addition, this device has been linked with the modulated amplitude laser beam technique where the scanner sweeps the object continuously with a variable beam, using rotating mirrors. With this system, the apparatus is able to capture the energy reflected by the object, comparing the shape of the reflected wave with the modulation emitted, and, thus, to calculate both the distance from the object and its spatial coordinates. As a result, all the points captured have 3D coordinates under a local reference system from the beginning, permitting them to be analyzed, processed, or exported to different formats, which is one of the advantages over traditional systems of capture (Bryan et al. 2004).

Thus, if we make a comparison between photogrammetry-based methods and laser-scanner systems, we find the following advantages of the latter over the former (Demir et al. 2004):

- It allows for direct acquisition of points from the object in 3D capture in real-time;
- It provides a large number of surface points, permitting a more realistic and complete analysis of the object;
- It is an excellent technique for the description and portrayal of irregular surfaces;
- The final results are available in a very short period of time.

4 Development of the Project

Cartographic techniques, or, rather, the methods and equipment for carrying out cartographic work, have evolved astonishingly in recent years, achieving not only great accuracy but also a speed of capture that allows the technique to be opened up to other fields hitherto beyond its scope. The use of prism-less laser systems will enable us to carry out data-capture experiments without prior discrimination of points (markers), permitting the capture of the complete human figure. If we add to this the high speed of capture of points (completely and without limits), the minimal post-processing needed to achieve a 3D digital image with real coordinates under a mesh, and the capability of making real measurements from the figure, this system offers us a process that in real-time is able to provide spatial data, where the space-time relationship is decided at the moment of capture. Our aim will be to obtain inertial parameters adequate for the biomechanical modeling of the human body, entailing the use of the anatomical points and interconnected segments under a system of local or real reference, where there exists a spatial relationship between these and the rest of the points that form the surface of the human body being studied.

The content of this paper will attempt to define a line of acquisition of data under these new systems and to analyze the mathematical algorithms necessary for application to metrical human heritage representations. We will attempt to design and develop a working base that can be used in heritage as a study of human movement in real-time. The purpose of this paper is to open a new heritage line of research into the modeling of the 3D human figure by means of innovative cartographic techniques and their possible application to the portrayal of movement. We thus aim to obtain a new working methodology that will make available increasingly reliable information on the kinematics of the anatomical markers of interest.

4.1 Objectives

This paper will attempt to define, and open a door to, a new system of capture and portrayal of the human figure as a step prior to the study of movement in real-time, attempting to develop, validate, and apply a working methodology. This methodology will include optimum ranges of parameters for the purpose sought, to permit direct application in disciplines and representations in which biomechanics plays an important role.

We will attempt to achieve the following general objectives:

a) Carry out an in-depth analysis of the mechanisms and parameters that may influence the acquisition of the human figure, from the point of view of modeling applications.
b) Develop a new methodology of data capture, based on a prism-less laser system, suited to the purpose at hand, and describing the optimum parameters and the technical and mathematical apparatus necessary.
c) Portray in digital form, by means of real coordinates, the 3D human figure in real-time, permitting measurements of it to be taken.
d) On the basis of the above results, set out the following specific objectives (See Figures 4 and 5).
   Objective 1: Capture of the image and formation of 3D model
   Objective 2: Analysis of its possible application to objects in motion
e) Obtain valid conclusions that will allow future lines of research to be proposed.

4.2 Development Plan

In developing this project, the steps illustrated in Figure 6 will be followed.

Historical and bibliographical review of the portrayal of the human figure. We will study the evolution of this discipline so as to have an optimum working base that will guarantee the optimal testing of the results that we aim to achieve. The most representative results and the most important contributions made in recent years will be briefly described.

Analysis of the different methods used in recent years. The methods that have used to date will be analyzed, as well as the mathematical apparatus employed in them, making a special study of the latest papers or theses in this field nationally and internationally. The aim of this step is to

Figure 4. Process of capture of the image and formation of 3D model.

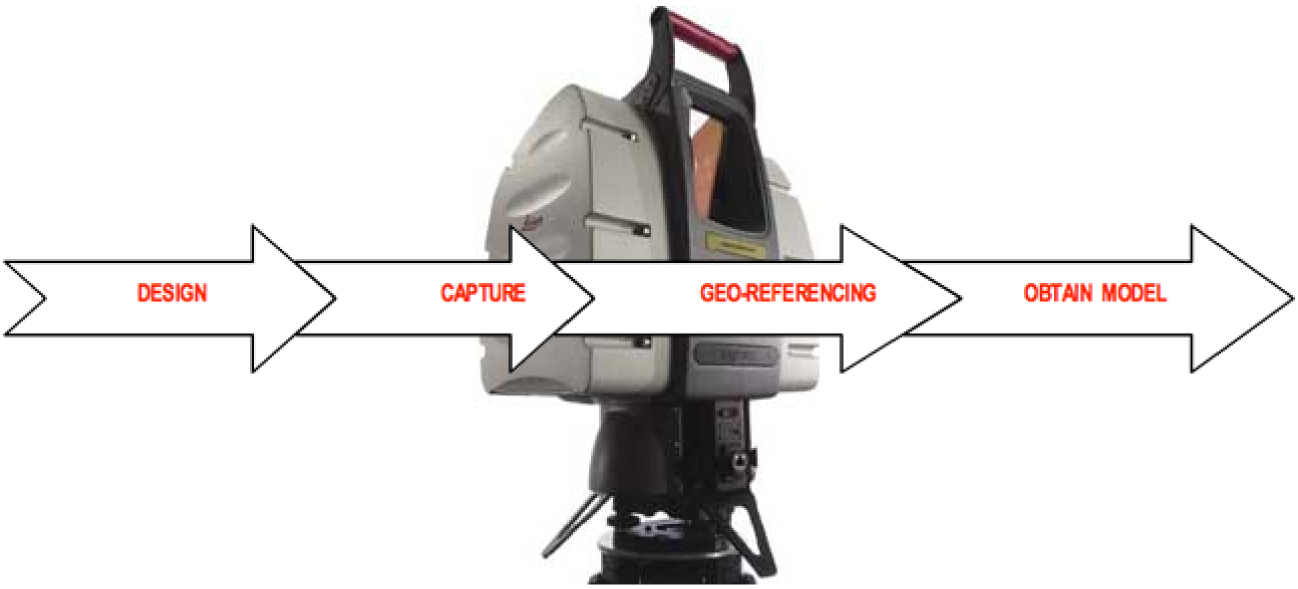

Figure 5. Objectives in the process of analysis and the application to a moving object.

obtain methodological states and values that can be applied directly to the project to assist and complement the proposed new system.

Review of advances and studies in progress in the short- and medium-term. In this phase, we will focus on the advances that are being made at university level, such as the work being carried out in the Faculty of Sciences of Physical Activity and Sport of the University of Granada, and in institutes and public bodies such as the Biomechanics Institute of Valencia, and the Biomechanics and Ergonomic Research Group of the CINEI (Centre for Innovation in Industrial Firms), or internationally through organizations and such as American Society of Biomechanics (ASB), International Society of Biomechanics (ISB), the Canadian Society For Biomechanics, Biomechanics World Wide, and prestigious publications.

Analysis of the current state of the art. We will review and analyze the current situation of the systems being used for biomechanical studies at both national and international levels. We will obtain a real vision of the state of the art to guarantee that the system proposed is novel and makes a direct contribution.

Description of prism-less laser systems. Laser systems will be described in depth, at the levels of mechanics, mathematics, application, and use. We will analyze methodologies, accuracies, optimal conditions of capture, etc.,

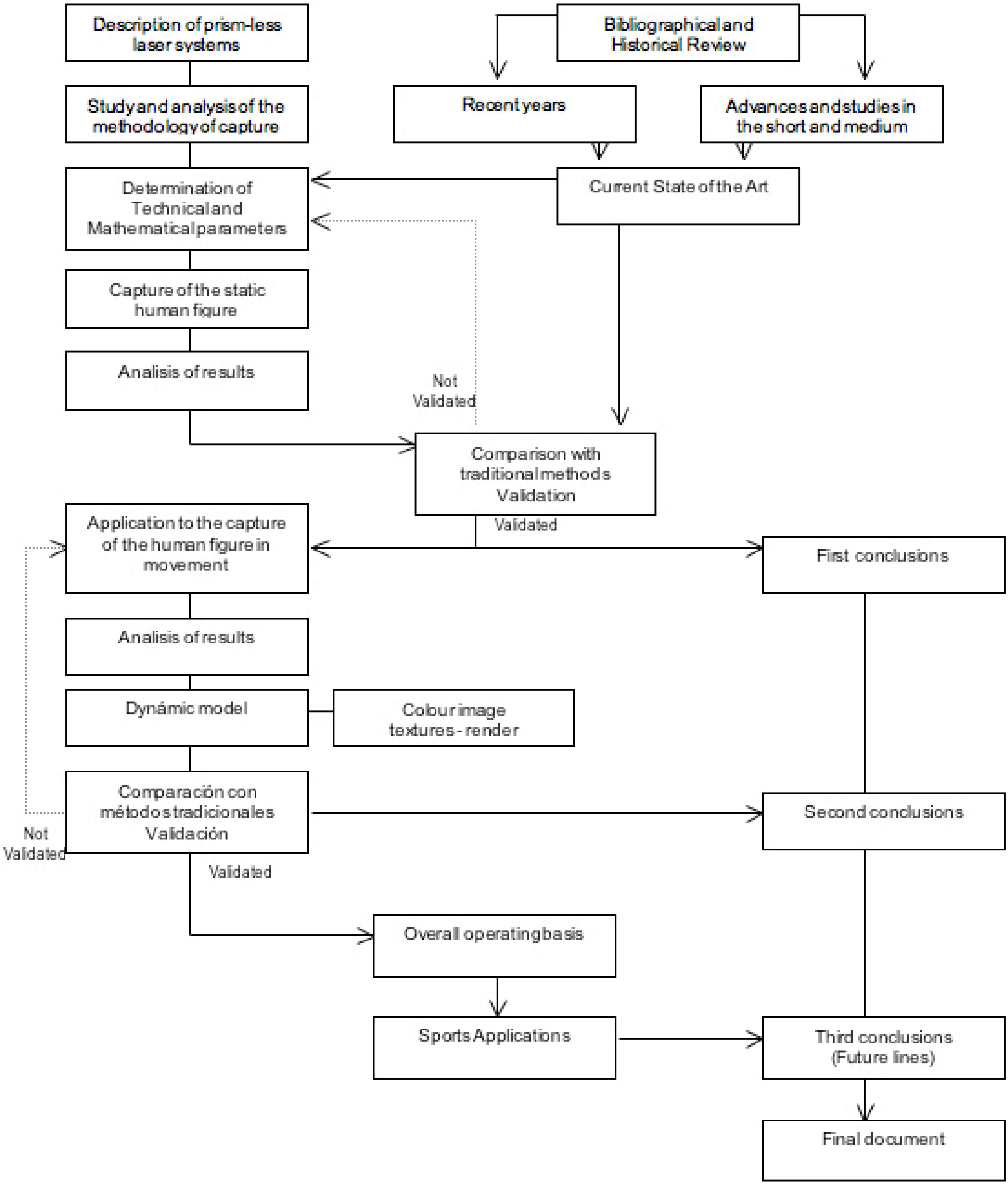

Figure 6. Plan of work and execution.

all complemented with practical examples in which these systems are currently being applied.

Study and analysis of the working methodology for the capture of the three-dimensional human figure by prism-less laser systems. We will define a working methodology valid for the capture of the 3D human figure by means of prism-less laser systems. 3D laser-scanner systems constitute one of the systems with the most promising future in work where precision is an essential requirement. For this, it is vital to parameterize the capture correctly and to prevent areas of shadow as much as possible (anti-aliasing). At this point we will make different tests, based on different working hypotheses, which will be fed back directly until an optimum data-capture situation is achieved.

Consideration of the most suitable technical and mathematical parameters for data capture. With the appropriate parameters of data capture and the working methodology established, we will be in a position to develop the mathematical algorithm on which the system is based. This will be described in depth, and validated in practice, demonstrating the objectivity, reliability, and validity of the system that can be applied to a sample of people.

Capture of the static three-dimensional human figure by means of prism-less laser systems. By strictly following the protocol previously determined and applying the technical and mathematical processes developed earlier, we will proceed to render different human figures. In the same way, we will attempt as far as possible to bring the system out of the laboratory so that the person is in a situation as close as possible to the real situation.

Analysis and validation of the results obtained. We will attempt to verify the strength and validity of the system and the results obtained by studying the data acquired in general and in particular, in order to establish statistical relationships between the results of the different groups of the sample. As a result, we will obtain a working hypothesis and a procedure for action, which will be applied later.

Modeling of the static three-dimensional human figure by information technology: Technical and mathematical basis of the procedure. This is the first rigorous attempt to create the first 3D model of the human figure in a digital medium, permitting it to be operated on with total freedom. In this phase we will develop the technical and mathematical apparatus necessary to generate such a figure.

Comparison with the results obtained by traditional methods: Advantages and disadvantages. First conclusions. The results will be evaluated and tested against other data and theories obtained from the bibliography on the subject and research being carried out at other institutions. A first group of conclusions will be obtained, which will be evaluated, and if valid will be an obligatory reference in the final conclusions.

Analysis of the application of the system developed to the human figure in movement. On the basis of the results obtained, we will proceed to analyze whether the system is valid for dynamic capture, working with the results obtained in the earlier phases and using "Cyclone" software, which offers a wide range of tools and working possibilities for 3D images. The resulting point clouds will be presented as detailed images in color, permitting the third dimension to be visualized from any angle.

Analysis of the results obtained. In this phase, we will be in a position to select, from the point clouds, those specific parts to be analyzed, and to introduce their codes and characteristics. In heritage, the principles and methods of mechanical engineering have to be applied to the study of human structures in order to better understand the functioning and the mechanical limitations of the different structures of the body: bones, muscles, ligaments, and so on.

Methodology for the modeling of the dynamic 3D human figure in an information technology medium: Technical, mathematical, and procedural basis. Once the analyses and necessary adjustments are complete, the system will permit us to define how to carry out the geometrical generation of the 3D model. As each point has a precise position (X,Y,Z), we have a wealth of digital information available. This is the starting point of the studies that may be needed, including measurements P2P (point to point) or the partial or total generation of meshes. We will attempt to obtain, on the basis of the 3D coordinates of the target points that define the subject, mathematical algorithms that give us values of velocities and accelerations, linear and angular, of the segments of the body. We will do this by using the digital results obtained by means of laser-scanning techniques, preventing or reducing to the minimum the systematic or random errors produced by the "signal-noise" ratio, which will involve adequate selection of the following: the resolution to discriminate small variations (*R*), the scanning frequency (*F*), the density of vertical and horizontal points (*dV* and *dH*), the accuracy or degree of agreement of the measurements repeated in identical conditions as the estimator of random error (*P*), and the accuracy of the measuring equipment as the estimator of systematic error (*E*).

As a starting point, the correlation among the different images obtained will be made by making spatial adjustments based on Helmert transformations, combined with the following minimum square techniques: polynomial adjustment techniques (Gregor and Kirkendall 1978); techniques of adjustment of coordinates and calculation of their temporal derivations; techniques based on finite differences of first and second order (Pezzack 1977); techniques based on the adjustment of the data to "spline" functions (Wood and Jennings 1979); techniques based on the digital filtering of the position-time data; and techniques based on Fourier series (Hatze 1981), evaluating and comparing these to develop the most suitable one for this new system of capture.

Comparison with the results obtained by traditional methods: Advantages, disadvantages. Second conclusions. The results will be evaluated and tested against other data and theories obtained from the bibliography on the subject and the research being carried out at other institutions. Special interest will be taken in comparing and contrasting these systems with photogrammetric techniques, attempting to analyze whether the disadvantages, issues, and/or restrictions of these methods have been solved: confined spaces (Woltring and Huiskes 1990); use of various sensors to obtain 3D images; limitation due to laboratory conditions in direct techniques; immediacy of results in indirect techniques (time variable); and so on. We will obtain a second group of conclusions which will be analyzed and, if considered valid, included in the final conclusions.

Obtaining color images (Thermo-regulation): Possible applications. In this phase, maps of intensity and texture will be generated through illumination and "rendering" techniques with the hope that they will offer results or a little light for certain high-level compositions. For this purpose, we will attempt to model with light, to define visual functions of shadows, to define spatial relationships, to analyze alternative angles, and to use shading algorithms, all conducive to improving the composition and/or portrayal.

Discussion of the results and comparison with the results obtained by traditional methods. Advantages and disadvantages. Third conclusions. The results will be evaluated and tested with other data and theories obtained from the bibliography and other research on the subject. A third group of conclusions will be obtained which will be an obligatory reference in the final conclusions.

Final operational basis of a complete process from capture to availability for study. This includes details of the methodology of capture and rendering of the human figure in continuous movement, the mathematical apparatus to be used, and the subsequent process of calculation. At this stage, we will be in a position to make summary description of the whole process so that it can serve as the starting point for subsequent studies or papers.

Analysis of the heritage applications of the system. With the results obtained, we will analyze and describe the possible applications of the system within heritage in general. For this, we will attempt to define, and obtain the parameters that define, the spatial localization of the human body, employing this localization as the subject of study. We will then be able to put forward initially different working alternatives, with both passive and active methods, analyzing the advantages and disadvantages of each.

Final conclusions of the study and proposed lines of future research. This stage will involve recapitulation and summary of the conclusions of each of the sections. These will be analyzed and classified depending on the results obtained. We will suggest lines of study and research for the future, depending on how the technical advances in laser systems of capture are developing or are going to develop. For this, we will analyze, as far as industrial secrecy permits, the research and development of the firms that possess these systems.

4.3 Means Used

The material requirements estimated for the execution of the project are the following.

3D Laser scanner: the HDS4500 is an ultra-high speed scanner by Leica Geosystems (Figure 7). The HDS4500 offers high speed, using a continuous laser beam rather than a pulsed one. Continuous lasers permit exploration at speeds from 100,000 points per second to 500,000 points per second, and offer a complete 360° field of vision horizontally, x ±135° vertically (azimuthally). It will afford great accuracy, even at long distances, thanks to the high intensity and the point of beam generated by each short-wavelength pulse. This makes it an ideal system for data capture projects with very short time windows.

These systems are based on HDS (High-Definition Surveying), the principal characteristic of which is the capture of a high density of data and images, richer than point-to-point measurements, permitting us to geo-reference in a local system of coordinates (X,Y,Z) or in another system of real coordinates. The most important characteristics are as follows:

- Radar-type laser-scanner of high accuracy and speed, using the pulsed laser system, with double mirror optics and servomotor mechanisms.
- Brightness: Operational in bright light and in darkness.
- Permits a volume of capture of 20,000 m^3 at 50 meters and 160,000 m^3 at 100 meters.
- Accuracy of capture greater than 6 mm at 50 meters and resolution greater than 1 mm at distances between 5 and 50 meters and angles of ±60 microradians.
- Vertical scanning density of 1,000 points/column and horizontal of 1,000 points/row.
- Accuracies in P2P (point to point) measuring to less than ±4 mm.
- Time of capture less than 5 minutes, depending on volume:
- 1 column/second for 1,000 points/column
- 2 columns/second for 200 points/column.
- Direct real-time interface with the computer.
- Integrated video camera with a resolution of 480 x 480 pixels in color.

Simple operation is important:

- Aim the scanner at the zone of interest.
- The video camera, integrated into the equipment, performs a rapid first capture, which is sent to the computer connected to it.
- The operator selects the desired area, the accuracy, the resolution, and the rest of the necessary parameters.
- The capture of the object starts. Inside the apparatus, two mirrors make a rapid and systematic sweep of the selected area by means of laser pulses. The "flight time" technique is used to measure each laser pulse, so it is not necessary to use reflectors (mark-

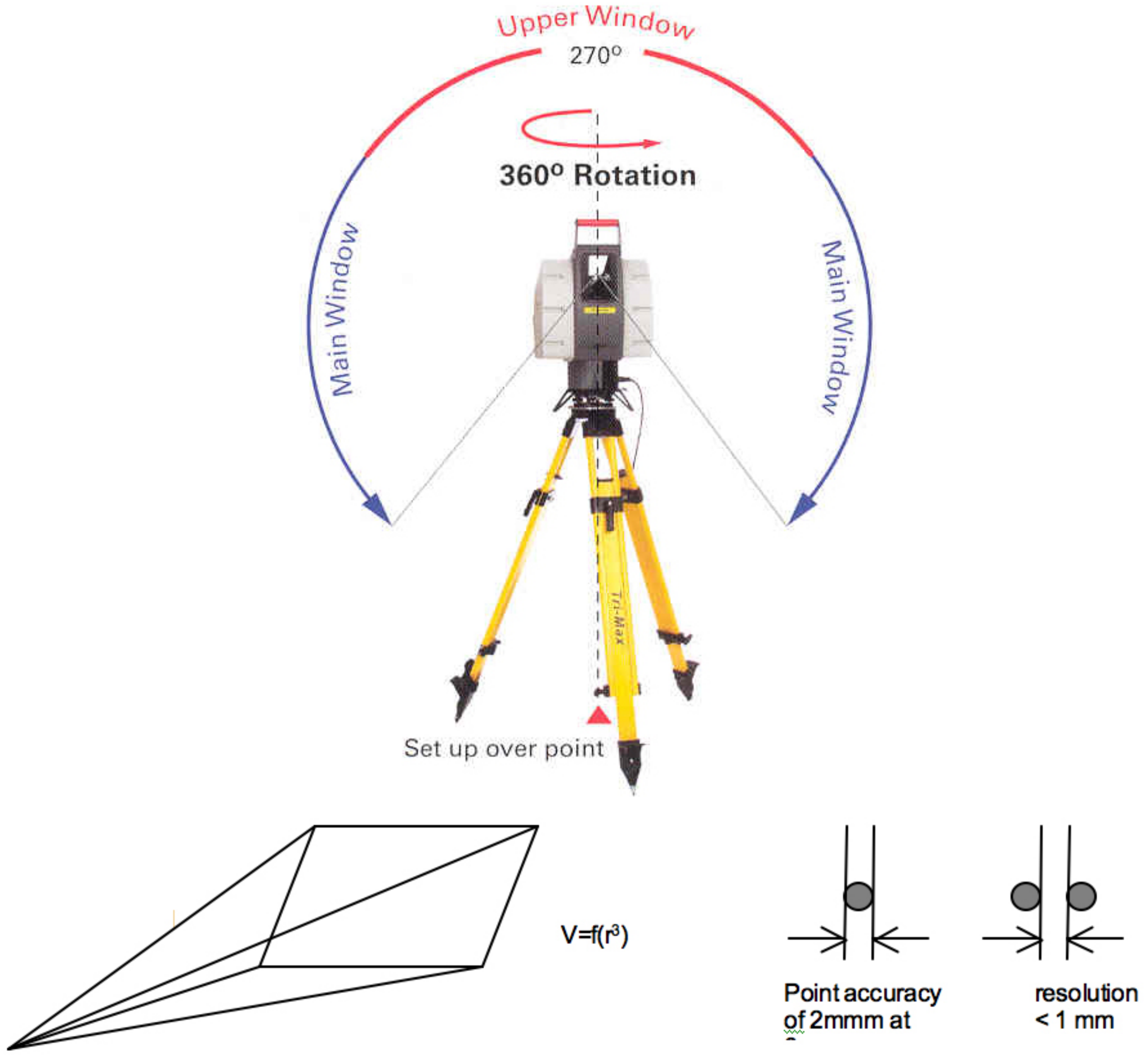

Figure7. Equipment used in the capture of data.

ers).

- For each laser pulse, the distances are calculated, and minute integrated optical decoders make the angular measurements, obtaining a first set of polar coordinates, which are transformed into Cartesian coordinates (X,Y,Z).
- The resulting positions are displayed graphically on the computer in real-time (as they are calculated).

"CYCLONE" Software by Leica Geosystems. This modular software on the PC is used to operate the Cyrax scanner, efficiently processing point clouds in 3D and managing 3D laser scanner projects. It enables the details of interest to be minutely recorded, permitting different scans to be combined rapidly and securely when only three common points have been accurately determined. The system possesses a wide range of tools for working with images and models in three dimensions. The most important characteristics are below.

- Total control of the scanner and of the processor from the PC, the scanner and the PC communicating through a standard Ethernet connection.
- Rapid capture of the digital video image.
- Detailed adjustment of parameters: accuracy, density of points, etc.
- Rapid conversion of clouds of points into surfaces of triangular mesh.
- Generation of digital models by means of meshes.
- Generation of surfaces and maps of intensity.
- Calculation of volumes from the mesh.
- 3D modeling from clouds of points, by means of intelligent algorithms.
- Records multiple scans with functions of superimposition, geometrical adjustment, spatial adjustment of coordinates, etc.
- Instantaneous dimensioning of distances between two points and from the scanner to any point of the object.
- Permits free movement, flight, zoom, and rotation of

3D models.
- Texturize the point cloud.
- Visualization of selected points with parameterized intensity.
- Filters to introduce data and information based on ranges of distance and intensity.
- Geo-referencing and transformation of points in space.
- Recording of multiple scanning processes.
- Measurement on the modulo (ΛX, ΛY, ΛZ), by means of P2P techniques.
- Export to formats: VRML, DXF, DGN, Text (X, Y, Z, color), PTS, Wavefront OBJ, among others.

A Portable Microcomputer will be used with the following characteristics.
- Windows 2000 (SP2 or higher), Windows XP (Professional or Home Edition, SP2).
- Monitor: minimum resolution 800 x 600 pixels.
- Pentium 4 processor, 2 GHz or higher.
- 512 MB RAM (1 GB recommended).
- SVGA - OpenGL graphic accelerator card.
- 10/100 Ethernet network card
- Hard drive: minimum 10 GB.

The installations of Leica Geosystems in Madrid will be used, as well as any others that may be considered adequate for completing the capture of data.

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