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# Development of a method for an automated generation of anatomy-based, kinematic human models as a tool for virtual clothing construction

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ABSTRACT

Product development in the garment industry is an iterative, empirical process, since no kinematic human models are available for the design/construction of functional and/or fashionable products. The required body measurements result from serial measurements with body scanners, in which the persons' data are recorded in upright standing posture. Particularly the product development for medical/orthopedic applications, sports or protection clothing require a high functionality and consideration of the characteristic posture of utilization. To achieve different body postures, a highly automated method was developed to transfer kinematic information on the scanned 3d surface data of individuals or size-specific standard figures. These surface data are extended not only by a skeleton but as well by muscle groups with constraints and rules for the motion to create a kinematic template, which can adapt automatically to different body postures.



## 1. Motivation

Product development in the garment industry has been an iterative, empirical process for decades, since no kinematic human models are available for the design/construction of functional and/or fashionable products. Body measurements, which are required for construction, result from serial measurements, in which the individual data are recorded nowadays in body scanners in upright standing posture. Based on these scanned surface data, standard body shapes (figures) of the upright standing posture are processed for various sizes and provided to the industry. Movement information are currently available primarily as skeletal data for ergonomic or computer-graphical application. In motion, e.g. forward bending of the torso, the body surface and body measurements change significantly. These changes can neither be reproduced with state of the art or commercial human models nor digitally included in assembly-technical product development. Particularly the product development for medical/orthopedic applications, sports or protection clothing require a high functionality and consideration of the characteristic posture of utilization. The garment designer needs the ability to transform scanned surface data recorded in upright standing posture into the characteristic posture of utilization and use these resulting 3d data as basis for pattern design. The intent of the research effort was the development of a highly automated method which enables the generation of a kinematic human model for clothing engineering from scan data of individual persons with little time effort without specific programming knowledge. Therefore, a musculoskeletal template based on MRI data and anatomic basic principles is developed.

## 2. Objective

The generation of various postures and motion sequences in the context of this research work is based on the recorded anatomical relations, whose closeness to reality is essential for the model quality. If the model anatomy is incorrect, no anthropometrically correct postures and surface can be created for the model. These

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postures serve as the base for three-dimensional garment construction and therefore directly influence the garment fit.

The anatomy to be represented includes the skeleton (bones and joints), the muscle system and their influence on the skin. Usually, no specific physical or virtual human models for the anatomy of the relevant individual are available. Therefore, the created human model follows general rules from human medicine and physiology, which limits it to approximating reality.

The development and utilization of the kinematic human model is independent of the gender. The approach will be explained for females in the following text. Synthetically created, three-dimensional standard figures are an alternative starting point to individual human models. The development is done as a process on different levels of detail. First, the general approach of using templates for animating 3d surface data is examined for a simplified model of a leg (cylinder) and validated. In this paper each template is a kinematic model. The difference of the template model to the kinematic model is the use of a naming convention for elements, e.g. sets of vertices, bones. This allows the automated modification of template models by scripts. To improve the mesh quality of the resulting 3d data a method is presented to change the net topology without losing information on the relationship between the template and the scanned data. These algorithms are used and extended to validate the principle of the development process. For this purpose, the scanned data of a leg are used. In the second part the lower part of a female body is considered. These approach in different levels was chosen to be able to validate each step easily without the possibility of overlapping side effects which can be overseen easily on a complex model. Testing and developing of software in iterations from simple to complex processes leads to more stable code and facilitates the development.

To fulfill the anatomic requirements the kinematic human model (skeleton and muscles) are based on MRI data of a real woman. These are connected to each other by anatomically given rules for movements which result in constraints for the different type of joints. The simple bones of the template for the sample leg are replaced in this development step by realistic bones and muscles which result in a much more complicated influence on the surface data. The automated adaption of the surface data of the template to the scanned surface data has to be extended for the additional bones as well. Therefore, an automatic segmentation of the surface data is proposed.

In the last development step, the process is performed for scanned surface data of different persons. For validation, the resulting deformed surface data for specific body postures are compared to scanned surface data in the corresponding position. To validate the usefulness of the resulting surface data, sample patterns are created for different body postures.

## 3. State of the art

The creating of a virtual human is a long-hedged dream of engineers, inventors and filmmakers. The development of digital human models began in the late 1960s in vehicular and aeronautics engineering with virtual models for the testing of vehicle interiors and comfortable accessibility of various control elements. Over the past decades, a wide range of digital human models (about 150) [1] were developed for various purposes and applications. The subject matter is so extensive, the connections are so complex and the degrees of freedom so great that not a single model fulfills all requirements at the same time. Because of the complexity of the human body and the huge range of research fields, the used human models differ significantly. No model fulfills all requirements at the same time. The desired applications have significant influence on the dimensions of the description: While, for instance, the ergonomic accessibility and posture analyses are important for anthropometric assessments, human models for movement and strain analysis, e.g. in sports medicine, are based primarily on insights from biomechanical engineering to precisely describe the functional view.

For the development of textile products, detailed anthropometric and biomechanical information of the surface are required. The currently available digital human models are inapplicable for the virtual design of garment products, especially for considering functional aspects for sports, medical and protective clothing. They either do not adhere closely enough to anthropometric basics or do not offer a realistic surface description, particularly for movement. Furthermore, body measurements and classification of the general population in the form of measurement tables are not sufficiently considered. A connection to elaborately created databases from current series measurements (e.g. SizeGERMANY), if anything, is primarily made in relation to the skeleton with restricts to anthropometric variables. Scalings to represent the 0.5–99.5 percentile of male and female models are done only by body height and weight. So far, no satisfying method has been offered to use a static posture of individual scanned data or previously provided standard body shapes to generate dynamically consistent human models from which the desired body postures can be defined and derived.

Extensive literature research proves the global interested of research in the subject topic. Engineering approaches to an optical recording of surface data and to skeleton generation are increasingly linked to computer-graphical methods to achieve an efficient modelling form for highly complex human shapes and their deformation in motion.

### 3.1. Surface models

According to [2], there are three approaches to the modelling of a virtual, three-dimensional surface model of real person: creative, reconstructive, and interpolative.

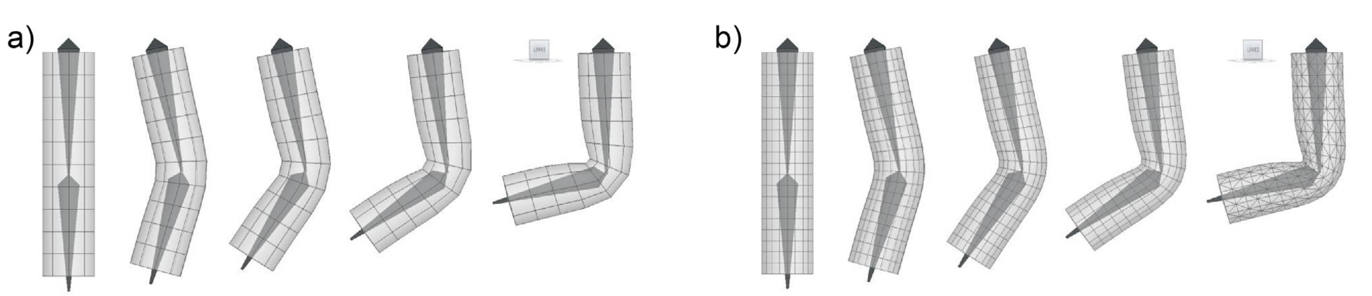


**Fig. 1.** a. Daeformation of a cylinder with a coarse net structure by two bones. b. Dbeformation of a cylinder with a fine net structure by two bones after interpolation of the weightings.