1

Understanding Human Motion: A Historic Review

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Summary. Understanding human motion is based on analyzing global motion patterns, rather than on studying local patterns such as hand gestures or facial expressions. This introductory chapter reviews briefly (by selection, not by attempting to cover developments, and with a focus on Western History) people and contributions in science, art, and technology which contributed to the field of human motion understanding. This review basically stops at the time when advanced computing technology became available for performing motion studies based on captured image data or extensive (model-based) calculations or simulations.

1.1 Introduction

Interest in human motion goes back very far in human history, and is motivated by curiosity, needs or methods available at a time. For example, a biomechanical perspective is characterized by the “need for new information on the characteristics of normal and pathological human movement” [35]. It is also possible to outline disciplines of science (e.g., mathematics) or arts (e.g., paintings, sculptures), relevant to human motion, just to indicate briefly the complexity of the subject. Obviously, different disciplines are interested in different aspects of the subject; biomechanics is, for example, focusing on human locomotion, with less interest in muscle models, and when correcting motion (e.g., of disabled children) by surgery, it will be exactly the opposite.

This chapter attempts to inform about a few developments which are of (somehow) joint interest for computer vision, computer graphics, and biomechanics. Those areas collaborate increasingly in research and developments relevant to human motion.

The following chapter could certainly be more detailed about the historic context of developments in the understanding of human motion at various periods of human history. For example, art was definitely a major driving force for many centuries for specifying human motion (see, e.g., comments
on da Vinci below), or Braune and Fischer were (at the beginning of 20th
century; see below) among the first to quantitatively measure human motion,
but their work was motivated by improving the efficiency of troop movement.

Many mathematical results had been found in the early civilizations of
Mesopotamia and Egypt, but a succession of Greek thinkers (starting with
Thales, in the 6th century)\(^1\) developed mathematics as a coherent logically
organized structure of ideas. We start our review at this period of time.

### 1.2 Classical Antiquity

The ancient Greek philosopher Aristotle (−383 to −321) published, besides
much other fundamental work, also a (short) text \(\Pi\varepsilon\iota\ Pi\omega\peia\sups{\varepsilon}\ \Pi\theta\omega\iota\omicron\omicron\n\)\[^2\] on the gait of animals. He defined locomotion as “the parts
which are useful to animals for movement in place”. The text is very read-
able, certainly also due to an excellent translation, and it contains discussions
of interesting questions (e.g., “why are man and birds bipeds, but fish footless;
and why do man and bird, though both bipeds, have an opposite curvature
of the legs”), links to basic knowledge in geometry (e.g., “when ... one leg is
advanced it becomes the hypothenuse of a right-angled triangle. Its square
then is equal to the square on the other side together with the square on
the base. As the legs then are equal, the one at rest must bend ... at the
knee ...”), or experiments (e.g., “If a man were to walk parallel to a wall in
sunshine, the line described (by the shadow of his head) would be not straight
but zigzag...”). This text\(^2\) is the first known document on biomechanics. It
already contains, for example, very detailed observations about the motion
patterns of humans when involved in some particular activity.

Sculptures, reliefs, or other artwork of classical antiquity demonstrate the
advanced level of understanding of human or animal motion, or body poses
(often in a historic context).

Classical antiquity already used mathematics for describing human poses
or motion, demonstrated in artworks that we have to consider individual poses
as well as collective poses (e.g., in Roman arts, a married couple was indicated
by showing eye contact between woman and man, possibly enhanced by a
painted handshake), and showed in general that motion and poses need to be
understood in context. Motion was only presented by means of static artwork;
the first dynamic presentation of motion was by means of moving pictures,
and this came nearly 2000 years later, at the end of the 19th century.

A charioteer with horses four-in-hand traditionally had the horses gallop
in a race, where gallop is defined as a certain step-sequence by the horses, also

\(^1\) We use the astronomical system for numbering years.
\(^2\) In close relation with Aristotle’s texts \(\Pi\varepsilon\iota\ Pi\omega\peia\sups{\varepsilon}\ \Gamma\eta\epsilon\nu\varepsilon\sigma\varepsilon\omega\omicron\omicron\n\) (On the
Parts of Animals) and \(\Pi\varepsilon\iota\ Pi\omega\peia\sups{\varepsilon}\ \Κ\iota\hnu\sigma\varepsilon\omega\omicron\omicron\n\) (On the Progression of An-
imals).