7 UBIAS systems in cognitive interpretation of medical visualization

The UBIAS systems described in the previous chapter, designed for analysing medical images, are developed quite rapidly as research has been conducted on analysing and cognitively categorising images of various lesions occurring within the central nervous system [41, 46].

What is novel, however, is research on UBIAS systems for analysing and interpreting images showing complex multi-object structures. One example of such images are views of foot bones. Such images can be acquired in three different projections: dorsoplanar, external lateral or internal lateral, which makes their computer analysis even harder.

UBIAS cognitive categorisation systems for the above images of foot bones will be presented in subsequent sub-chapters.

7.1 UBIAS systems for semantically interpreting foot visual data

The cognitive analysis of images showing foot bones has been conducted using formalisms of the linguistic description, analysis and interpretation of data, which include such formalisms as graph grammars as well as by identifying and intelligently understanding the analysed X-ray images of bones of the foot.

In order to perform a cognitive analysis aimed at understanding the analysed data showing foot bone lesions, a linguistic model was proposed in the form of an image grammar, the purpose of which is to define a language describing the possible cases of foot bone layouts which are within physiological norms and the possible lesions of foot bones.

The purpose of the research work conducted was to determine the appropriate formalisms and to check their utility for executing cognitive analysis of the foot bone images considered using this class of medical information systems. This utility will be measured by the effectiveness of executing a job whereby the system detects lesions indicating the presence of selected disease units, among which the following have been distinguished: fractures, deformations, bone displacements and the appearance of an additional bone. The lesions described can be further divided into:

- various types of foot bone fractures;
- degenerations leading to skeleton deformation;
- bone displacements;
- the appearance of an additional bone among foot bones;
- the appearance of hematomas, calcifications and various irregularities in the structure of foot bones.
Cognitive reasoning methods were used in this project to detect all the above groups of pathological phenomena related to foot bones. The results achieved, as will be proven, confirm the suitability of the cognitive approach, although the unanimous identification of all disease units turned out to be extremely difficult due to slight changes in the input data (images) which were used to take the decision to classify the case under consideration to a specific disease entity.

Cognitive analysis methods were initially used for foot X-rays to process images taken in the dorsoplanar projection. This is one of the possible projections in which images are acquired in diagnostic examinations of the foot, and it is the one most frequently used in injury radiography.

However, before foot visualisations underwent interpretation analysis, it was necessary to execute a sequence of pre-processing operations which helped to extract all bones comprising the foot skeleton from the X-ray image. This stage corresponds to executing the information overload stage during the cognitive resonance process as it allows a significant quantity of data that has no impact on the final diagnosis to be eliminated. To complete this stage, it was necessary to segment the image, label the detected bones, determine their centres of gravity, which centres would then be represented by the apexes of graph descriptions introduced. After its proper segmentation, the image showing bones was subjected to median filtration to smooth out minor irregularities of the contour. Such operations are described in one of the authors’ publications [67, 68] in which the same operations were used to segment wrist bones.

Completing the necessary preprocessing operations yielded binary images showing contours of all bones. Further analysis was conducted for images so processed to create the graph representation for all the projections considered later.

### 7.1.1 Analysis of foot images in the dorsoplanar projection

The analysis of foot bones in the dorsoplanar projection led to defining a graph used for a model description of the foot bone skeleton (Figure 7.2) which utilises known anatomical regularities of this part of the lower extremity (Figure 7.1).

![Fig. 7.1. Names of bones for the dorsoplanar projection of foot images. Source: own development](image-url)