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Generation and Validation of Osseous Fracture Patterns by Forensic Analysis

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ABSTRACT This article presents a method for the generation of bone fracture patterns and their automatic validation through the use of forensic analysis. A tool has been designed that allows the generation of a fracture pattern interactively and guided by the system, based on the study of real cases of fractures. This tool assists the specialist in obtaining fracture patterns according to certain rules taken from the statistical analysis of real cases. Additionally, a parametric fracture pattern generator has been developed. This autonomous generator is able to obtain fracture patterns according to forensic case studies. Once a fracture pattern has been generated, by using one of these two methods the system also provides the validation of this pattern based on a forensic analysis, indicating the feasibility of the fracture pattern being valid and explaining the causes of its validity or non-validity. In addition, these tools provide an analysis not only of the probability of a pattern being correct, but also whether it is capable of detecting some limit patterns that could be valid if experts indicate this circumstance. The system is not closed to new cases, it being possible to include new forensic analysis. Both the interactive tool and the automatic generator, have been validated by experts. The automatic generator tool has been checked for feasibility with forensic statistical analysis. Finally, a usability study was carried out to assess the intuitive use of the interactive tool.

INDEX TERMS Automatic systems, bone fracture, forensic analysis, fracture pattern, generation tools, traumatology, usability, validation tools.

I. INTRODUCTION

A fracture pattern is a representation of the fracture zone of a bone. Normally fracture patterns are extracted from medical images of patients with some trauma. One possible use of the fracture patterns generated in this way is their application to 3D geometric bone models, in order to simulate geometric fractures with a realistic appearance. Generating validated fracture patterns allows us to obtain different types of fractures, including unusual cases and fracture cases that sometimes cannot be observed, in order to create a bone fracture bank. These fractures can serve as input to a simulator or training tool for fracture reduction performed by specialists. Forensic analysis uses the fracture patterns to deduce data about causes and input parameters about an injury.

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In this article, an interactive fracture pattern generator based on forensic analysis is presented. The tool allows the generation of bone fracture patterns according to certain rules. These rules are established through studies of real fractures. Subsequent forensic case analyses can be incorporated to the tool as they occur. This interactive generator also allows the validation of the fracture pattern through a statistical analysis. Therefore it also provides information about valid or invalid fracture patterns. In addition, it would also be possible to use it to guide specialists in the generation of fractures for their application on geometric models in the future. This tool is open to new rules and analysis from data obtained from new forensic analysis of real bone fractures.

The previously described tool allows us to create a fracture pattern. A parametric fracture pattern generator that automatically obtains new patterns accordingly with the rules established by forensic analysis has also been developed. The fracture pattern has been parameterized, obtaining an

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