The Internet-Based Medical Expert System ToxoNet

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Background

Toxoplasmosis is the disease caused by a parasite called Toxoplasma *gondii*. Whereas immunocompetent individuals usually are not threatened of any consequences, unborn children are exposed a high risk of sustaining severe eye complications in case of transplacental infection. Transplacental transmission of the parasite is possible under certain circumstances: only infection of a seronegative woman (termed as primary infection) may be dangerous for the unborn, whereas infection before pregnancy with persistence of immunity (called latent infection) protects the unborn child. Immunologic methods for demonstration of antibodies in serum and body fluids are the main tools for detection of toxoplasma infection. The most widely used tests are the Sabin-Feldman dye test (SFT) and the Immunosorbent agglutination assay (IgM ISAGA). The stage of infection (primary or latent) can be derived from a sequence of investigations based on SFT and IgM ISAGA [1-3].

Objective

ToxoNet [4] is a knowledge-based system intended to provide automated decision support to the clinician about a possible affection of a pregnant woman and, thus, a probable threat for the unborn. The results are derived from analyzing the outcome of SFT and IgM ISAGA tests performed in terms of the obligatory serological screening program of pregnant women. ToxoNet is accessible from within a World Wide Web browser located on any computer equipped with a connection to the Internet. Apart from the possibility to investigate a patient's state resulting in an interpretation consisting of a diagnosis and a therapy recommendation, the system also enables the physician to modify the inference mechanism by manipulating the underlying knowledge base.

Material and Methods

To be able to categorize the blood samples of a patient, the meanings (diagnosis and therapy recommendation) of particular constellations of SFT and IgM ISAGA have to be converted into a representation suitable for automatic processing. Since generation and modification of this knowledge has to be possible in a graphical manner, a decision graph consisting of nodes, edges, and transitions came into use, that can be drawn like in any drawing program. All nodes have to be connected directly or through other nodes with the root node, where the inference procedure starts at.

The inference process of ToxoNet interprets the decision graph (knowledge graph) as finite state machine, nodes correspond to states, edges to transitions. The conditions determine, which transitions are selected during an inference. By iterating over all available test results of a patient, ToxoNet passes through the graph, finally arriving at a particular state. Every state is assigned a diagnosis and a therapy recommendation, thus, every state is a possible final point of inference.

Since certain time intervals have to be kept between subsequent tests to guarantee a correct interpretation, and in order to take the differences in immune reaction of various patients into consideration, every transition is assigned a fuzzy duration. These fuzzy durations determine the time interval to be kept between two testings and are realized as fuzzy sets [5,6]. They are used during inference to assess and report testings, that otherwise may cause incorrect results [3,4,7].

Results

ToxoNet was splitted into three major parts that are all based on a client/server architecture: ToxoServer, ToxoBuilder, and ToxoApplet [4].
ToxoServer forms the server module of ToxoNet and is used by both, ToxoBuilder and ToxoApplet, to perform their tasks. ToxoServer is responsible for communication management, database access, and performing inferences on patients' data.
ToxoBuilder, the first of two client modules, contains a graphics-based knowledge acquisition system enabling the modification of ToxoNet's knowledge base (see Fig. 1). ToxoApplet finally provides an easy way to evaluate a patient's blood samples by triggering the inference mechanism of ToxoServer. An example of an inference result as displayed by ToxoApplet is presented in Fig. 2. Both client modules are realized as applets and accessible via the WWW.
ToxoNetBase—the knowledge base of ToxoNet—is part of the MedFrame database [8] and comprises 45 states that are interconnected with 92 transitions, the depth of the knowledge graph is four [4].

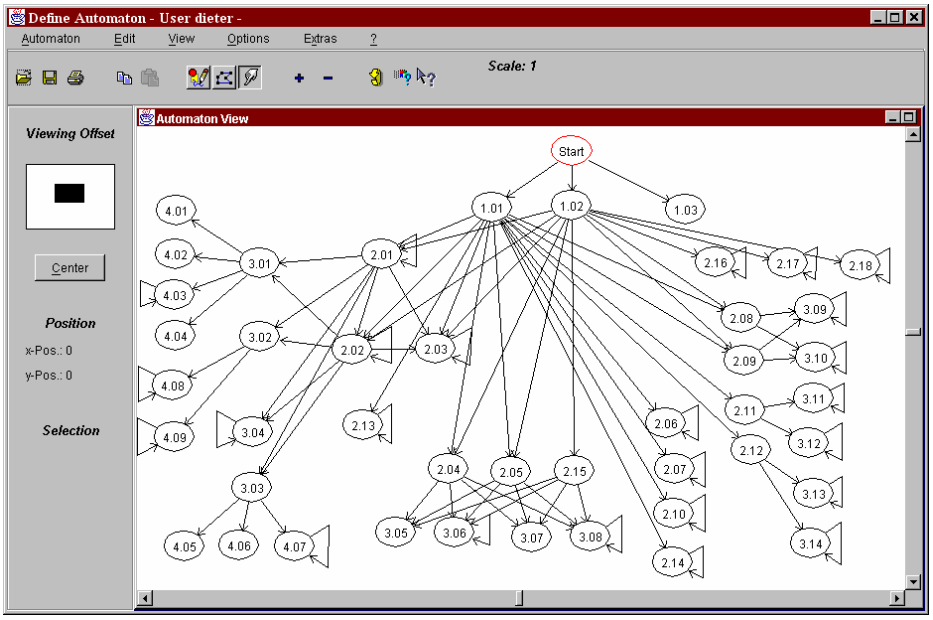

Fig. 1: The user interface of ToxoBuilder

Technical Specification

ToxoServer has been programmed with the Java Development Kit 1.1.7, whereas ToxoBuilder and ToxoApplet have been written with Java 2 Software Development Kit. Due to Java's platform independency ToxoServer is runnable on any operating system the Java Runtime Environment is available for. Since ToxoBuilder and ToxoApplet are both Java

applets, they can be executed inside of any Java 2 compliant WWW browser, or—if older browsers are used—the Java PlugIn takes care for correct execution.
Although Java is an interpreted language, ToxoBuilder and ToxoApplet run in a considerable manner even on less powerful computers. In contrast, a rather fast connection to the Internet would be preferable to shorten response time [4].

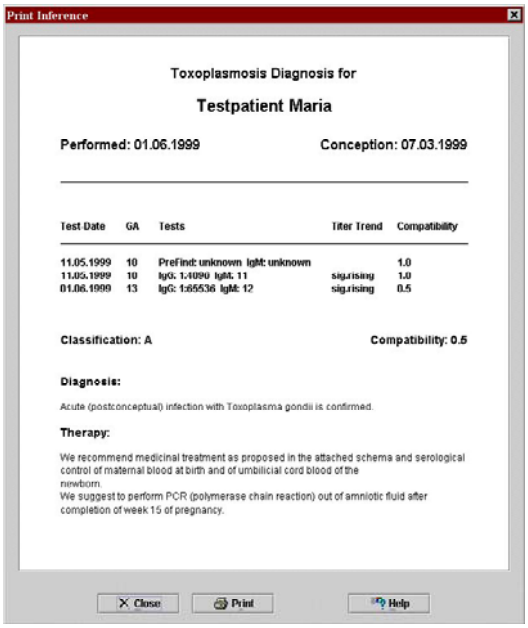

Fig. 2: Interpretative report as generated by ToxoApplet

Conclusion

ToxoNet provides the physician with a powerful tool for automated decision support in the field of toxoplasmosis and broadens the application of computer supported detection of toxoplasma infection to the World Wide Web. It does not only facilitate routine laboratory work but also assures quality standards for therapy.

References

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