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Status of IADA: an Intelligent Assistant for Data Analysis in VLBI

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Abstract

A faster and semiautomatic data analysis is important if the VLBI procedure shall be accelerated. Most of the tasks during the VLBI data analysis are very complex and require typical knowledge-based techniques. Thus, a Knowledge-Based System (KBS) called IADA (Intelligent Assistant for Data Analysis in VLBI) is being built which can be adapted to different geodetic VLBI software packages. The concept of IADA is described and it is shown how the knowledge about the VLBI data analysis process can be modeled and applied to the data analysis by the problem solving component of the KBS, to automate the data analysis. An interface has to be developed to transfer data and information between the existing software, e.g. the Mark III data analysis software package SOLVE, and IADA. The concept of the interface and the data flow between the KBS and SOLVE is described.

1. Introduction

The VLBI data analysis is a very complex process and needs a lot of manual interactions. It is very time consuming and a partial automation would be very useful to accelerate the VLBI procedure in particular with regard to the increasing number of geodetic observing sessions to be expected in the future. Most tasks of the geodetic VLBI data analysis require a comprehensive knowledge of the whole procedure of data analysis. Thus, a *Knowledge-Based System (KBS)* for support and guidance of the analyst is developed at DGFI to automate the geodetic VLBI data analysis. In this KBS the knowledge about the data analysis is stored and processed according to specific rules and instructions. The concept of an *Intelligent Assistant for Data Analysis in VLBI (IADA)* will be described in section 3.

The KBS can be adapted to different geodetic VLBI software packages by developing an interface between the existing data analysis software and IADA. The interface is used to transfer data and information between both the existing software and the KBS. Whenever the latter is activated the interface collects all necessary data from the database. This information is evaluated by the KBS and possible errors are corrected. The results are transferred back to the existing software and the regular analysis is continued. At present the interface is being built for one of the most widely used geodetic VLBI data analysis software packages, called SOLVE [1]. The concept of the interface and the data flow between IADA and SOLVE will be described in section 4.

2. Advantages of a Knowledge-Based System

Knowledge-Based Systems are software systems in which the knowledge about a problem domain is isolated and stored in a so-called Knowledge Base (KB) and is processed and evaluated by a domain-independent problem-solving component. Modifications of the KB as well as its extensions do not influence the problem-solving component. Only the KB has to be modified to adapt the KBS to new situations or tasks.

A KBS can be used to administer, store and evaluate specific knowledge needed for VLBI data analysis, to provide targeted information for the user and to solve the complex tasks within the data analysis automatically. It is less susceptible to errors, allows to conserve the analyst's knowledge and to check his/her decisions. Moreover, it can be used to guide and to support the analyst during the data analysis, to evaluate situations, to solve new problems and to analyse and check the data and the results. The KBS can be used as a teaching system for less experienced analysts and to exonerate the analyst in his/her routine work.

3. Concept of the KBS

The most important and even critical task when developing a KBS is to build the KB, i.e. to collect, structure and organize the knowledge about the VLBI data analysis (*knowlege acquisition*) and to store it in the KB (*knowledge representation*). The efficiency of a KBS depends on the quality of the knowledge within the KB, which should be modular, flexible and extensible. Several knowledge representation techniques are applied to store the knowledge in the KB:

- *Frames* to represent objects. They consist of several slots to describe the attributes of the object. Figure 1 shows an editor to administer frame-based knowledge about VLBI stations in the Knowledge Base of IADA.
- *Behaviors* to change the attributes of an object.
- *Prolog* to analyse a situation, e. g. to check the clock parameterization.
- *Rules* to model knowledge which depends on conditions. Rules consist of a condition part and an action part which is carried out if the condition part is true.

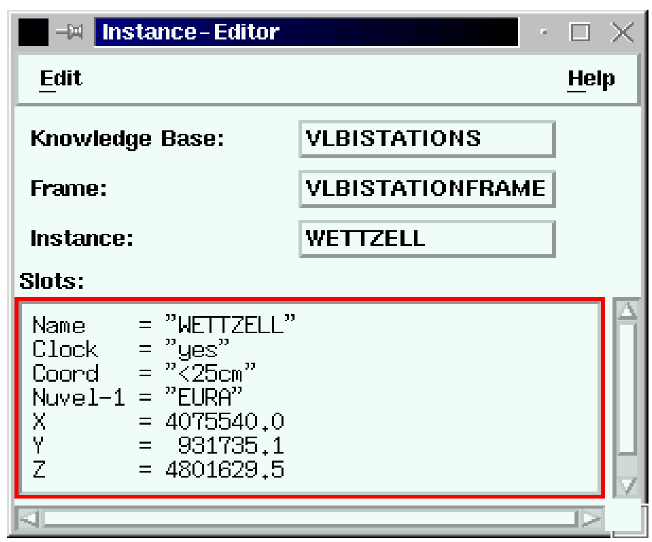

Figure 1. An editor to administer frame-based knowledge.

The representation of the knowledge about the VLBI data analysis using these formalisms is described in more detail in [2].

The structure of the Knowledge Base of IADA is shown in figure 2. The KB contains several components to be modular and easy to maintain as well as to fulfill different tasks like supervising the data analysis, evaluating current situations and deriving a qualitative description of a situation, detecting problems, treating specific situations, solving problems or simulating new situations. The components of the KB are:

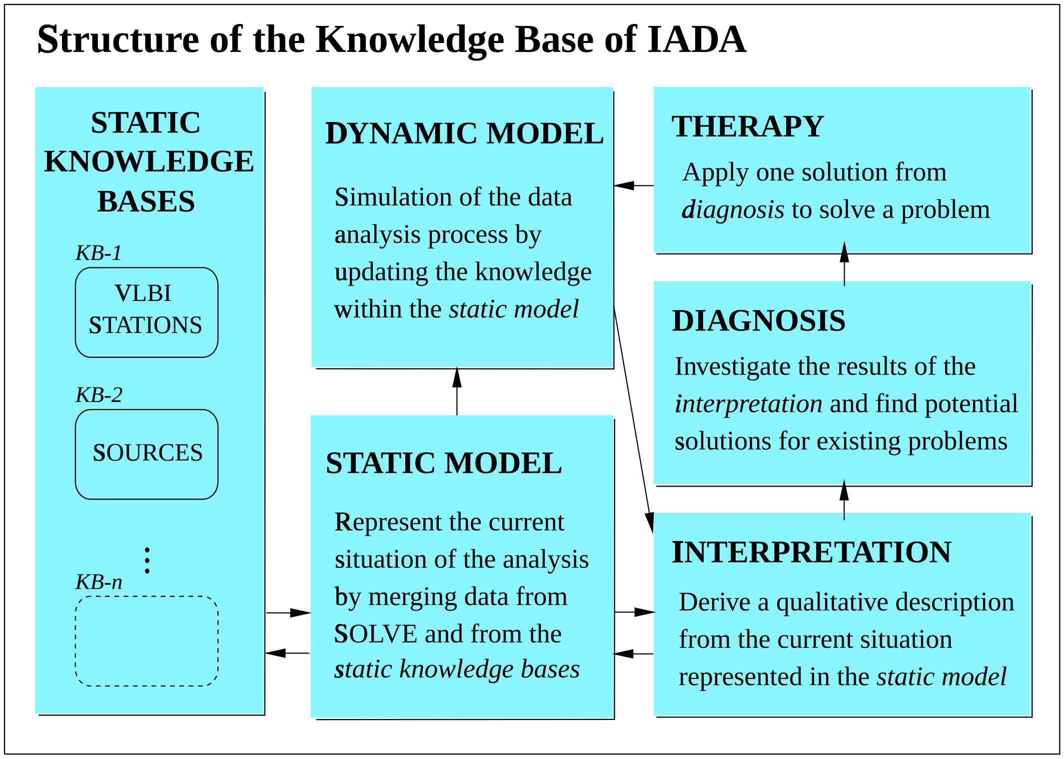

Figure 2. Structure of the Knowledge Base of IADA.

Static Knowledge Bases The static KBs contain general knowledge about the VLBI data analysis which does not depend on the current experiment. Normally the static knowledge bases don't have to be modified during the data analysis.

Static Model The current situation of the analysis is represented in the static model of the KB. This situation is generated by merging static data and information from the static knowledge bases and dynamic information about the status of the analysis which has to be obtained from the VLBI analysis software via the interface. The dynamic knowledge changes during the data analysis depending on the current situation.

Dynamic Model The dynamic model can be used to simulate the analysis process by continuously updating the parameters of the static model. Thus, the system is able to predict the effects of possible changes of the static model and to verify possible solutions of detected problems by using one or several of the components described below.

Interpretation This component evaluates the current situation represented in the static model. It investigates the parameters of the static model and derives a qualitative description of the situation by using rules.

Diagnosis This component evaluates the results of the interpretation, detects possible problems and finds potential solutions for existing problems.

Therapy The results of the interpretation and diagnosis are applied by this component to solve an existing problem.

Due to the modularity of the KB and the mutual independence of its components the analyst is able to use the KBS in different ways. One possible application could be to interpret the current situation, to find possible solutions of a problem, to apply one of these solutions and to use the dynamic model to simulate the effects of this solution. The results may be investigated by the interpretation component and compared with the original situation. On the other hand the analyst is able to simulate the effects following his/her own solutions.

4. Data Flow between SOLVE and IADA

The system interface is being developed to extract data and information from SOLVE and to transfer them to IADA. These data are processed by the KBS to control and/or automate the data analysis. Figure 3 shows the data flow between SOLVE and the KBS when the latter is used to control the VLBI data analysis as a background process. The KBS starts to check the current parameterization in SOLVE any time the analyst is going to start the least-squares solution. Thus, the interface reads the information entered by SOLVE into so-called *scratch files*. The information is transferred to the KBS which builds up the static model according to the current analysis situation and starts the interpretation and diagnosis of that situation. If problems were detected it tries to find potential solutions and applies one of them by updating the parameters of the static model. Then the user is asked whether the solution found by the KBS is correct or not. The KBS tries to find another solution unless the analyst does accept the solution. If the problem is solved the parameters of the static model are extracted by the interface and stored in the scratch files which are used by SOLVE. Finally, the analysis is going to be continued in SOLVE.

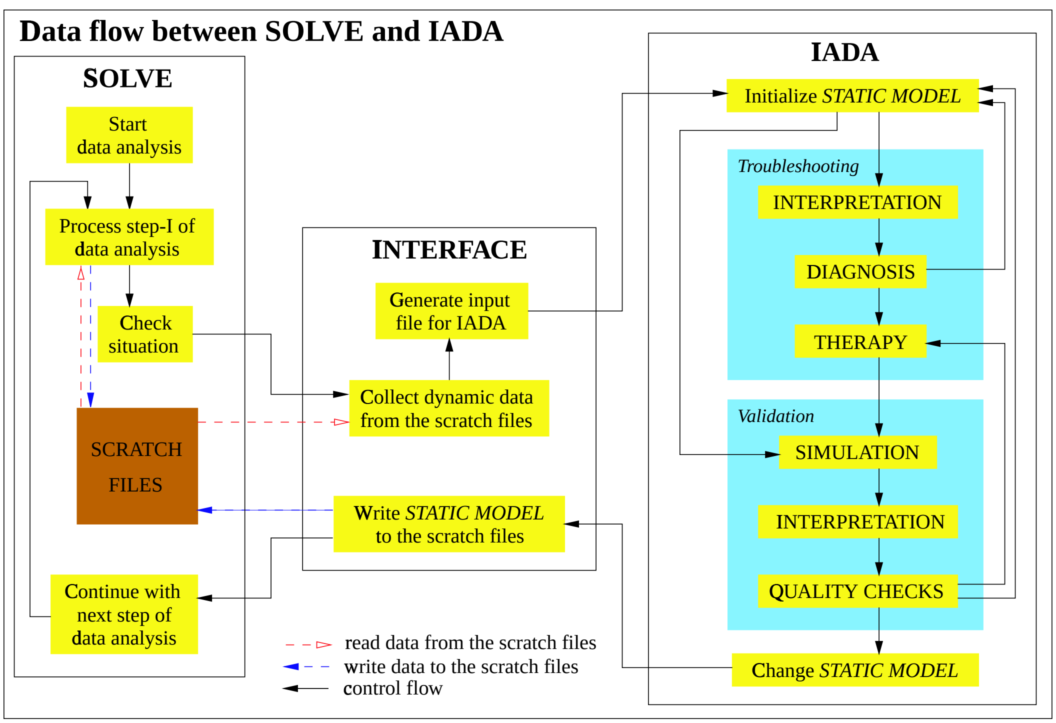

Figure 3. Data flow between SOLVE and IADA.

Figure 4 gives an example of a message which is generated if a problem occured. The analyst has to accept the solution found by the KBS, i.e. he has to confirm the message; if he does not, the KBS tries to find another solution. As soon as the analyst accepts the solution the regular VLBI data analysis will be continued in SOLVE.

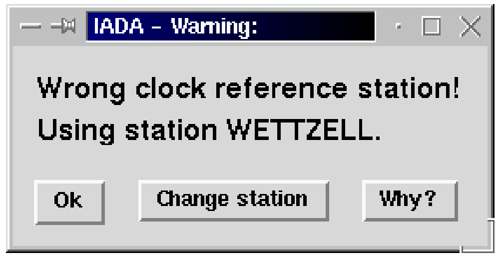

Figure 4. An example of a warning message generated by IADA.

5. Conclusions

The application of knowledge-based techniques for the automation of the VLBI data analysis brings many benefits because they allow an explicit modelling of the multifaceted knowledge needed for these tasks. Thus, the knowledge of several analysts can be conserved and applied by the KBS to automate considerable parts of the data analysis. The importance of the Knowledge Base of a KBS has been pointed out and the modular structure of the KB of IADA has been described. This modularity allows the use of the KBS for several tasks like interpretation, diagnosis and simulation. The interface between the VLBI data analysis software package SOLVE and IADA allows the exchange of data and information between these two systems to control and/or to automate by the KBS the regular analysis done in SOLVE.

6. Acknowledgements

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