Annotation: A Support for Co-interpretation

Guyet Thomas
CNRS/TIMC & LIG, Grenoble, France
E-mail: thomas.guyet@imag.fr

Abstract

Clinicians are interested in interpreting biomedical time series data to understand patient records. This paper proposes a new co-interpretation approach based on a "structural coupling" between two autonomous agents (a clinician and a machine) to support clinicians in their interpretation task.

From an Enactive point of view, the interpretation cannot be autonomously performed with direct knowledge exchanges. Then, annotation seems to be a core concept to enable mutual understanding and to preserve the required autonomy of each interpreter.

The CATS system has been developed to be coupled with a clinician. It autonomously annotates time series data and evolves through its annotation experience.

1. Interpretation

In the large range of interpretation assumptions of Iser [8], there is interpretation where there is a "gap between what is to be interpreted and the register into which it is translated" (p. 83). The interpret had to bridge the gap between the data and the meaning that he can construct from it. There is no predefined meaning in the data. The meaning emerges for the interpreter in his own world of meaning constructed from his past experience.

Therefore the interpreter is seen as an Enactive system. Varela et al. [12] define an Enactive system as a system that brings forth a world while it is built by it. We can raise a link between this definition and the case of a world of meaning. The interpreter elucidates meaning from the data and at the same time refrines its own perceptions and knowledge.

We separate perception and knowledge refinements to highlight that the meaning is caught in a vice between the uncontextual meaning creation and the meaning appropriation circular processes.

Meaning construction is a forms/meaning issue. The meaning has to be abstracted from the data based on characteristic features (forms) identified by the interpreter. Then the meaning is dependent on the perception capabilities of the interpreter, but perceptions are also modified by the extracted meaning by focusing the interpret attention. Consequently, the interpretation progressively makes consistent forms and meaning in a circular movement.

Meaning appropriation contextualized the meaning in construction in the interpreter knowledge acquired from past experiences. It involves the interpreter in another circular movement in which his knowledge is enriched by new meaning and at the same time it constraints the meaning elucidation.

To resume, the interpretation is the result of the interpreter course along the two indefinite nested circles in which the interpreter is involved to construct the meaning and to appropriate it.

2. Collaborative interpretation

The co-interpretation is a common interpretation performed by two agents. The expected aim of a co-interpretation is to benefit from two different points of view on the data and consequently to improve the interpretation performed by individual interpreter (i.e. make converge the interpretation, reduce the gap between the data and the meaning or speed up the interpretation).

In our application, the collaborative interpretation is performed by two cooperating agents, a man and a machine. A human expert is recognized as able to take accurate decisions in rather complex situations, by integrating a wide range of contextual information and keeping a global outlook over the data at hand. Conversely, the machine is able to process large amounts of data under complex numerical constraints.

The collaboration "occurs when two or more agents work together in a common environment to more effectively reach the maximal union of their goal" [2]. In [4], the authors define the main characteristics expected for man-machine collaboration system based on the study of man-man cooperation. Following these authors, the system must:
• operate within an acceptable framework of coordination,
• be able to recognize and accept the collaborator’s goals when declared,
• be able to interactively work toward super ordinate goals in solving complex tasks,
• offer alternative solutions to the problem addressed,
• operate to support the formation of new attitudes (adaptation).

The mixed-initiative approach [7] appears to date as the more elaborated tentative to achieve these characteristics. In a mixed-initiative system both the system and the user have balanced contributions for problem solving.

In the same vein, we propose an approach based on a “structural coupling” between man and machine to reach the collaboration. The man and machine “may become reciprocally structurally coupled through their reciprocal selection of plastic structural changes during their history of interactions. In such a case, the structurally plastic changes of state of one system become perturbations for the other, and vice versa, in a manner that establishes an interlocked, mutually selecting, mutually triggering domain of state trajectories” [9]. We point out three differences between a mixed-initiative approach and the proposed structural coupling approach:

• the role of our system is not to recognize the human needs in order to assist her/him, but to contribute in a balanced way to the solution,
• in our system man and machine share a common goal,
• the adaptation during the problem solving process is central in the structural coupling approach.

In this context, interpretation is not considered as a context-free attribution of meaning, but rather as grounded in each agent’s experience. There is no prevalence of one agent on the other, rather, there is a possibility of learning and discovery for both agents. This kind of partnership is rather meant to allow a co-construction of meaning, in which the interpretation of facts is not defined beforehand by one of the partners, but co-constructed in the course of their interaction.

Such a structural coupling cooperation raises the question of how the two agents can share knowledge without reducing the structural coupling substance. In fact, the knowledge can not be directly exchanged, otherwise agents do not work anymore in their own world of meaning and then the co-interpretation process is no more enriched from various points of view and the structural coupling between agents collapses. Annotation appears a core concept to cope with this difficult issue.

3. Annotations

An annotation is defined by Bringay et al. [3] as “a particular semiotic content linked to a target. The target can be a collection of documents, a document, a segment of document or another annotation. Each annotation has a content, materialised by an inscription. It is a trace of the mental representation elaborated by the annotator about the target. The content of the annotation can be interpreted by another reader. The anchor links the annotation to the target”.

An annotation is linked to a target and then it is a part of the virtual environment (constituted by the data and the annotations) shared by the two agents.

In a way similar to the talking heads of Steels [10], which interact to build a shared lexicon, based on their independent perception, analysis and manipulation of geometrical figures, we propose to consider both the clinician and the machine as agents who share a common virtual environment, and mutually interact using annotations manipulations to progressively refine their interpretation.

Annotation receives a growing interest in the co-design field and has been shown to support the dynamics of co-operation [1]. Annotations may be seen as tangible marks that can be managed by the agents, i.e. they enable the co-construction of objects. They may also be seen as tangible signs that make sense, i.e. they are the materialization of contextual knowledge that may be shared among the agents. According to this principle, each agent is in turn given the possibility to observe and interpret annotations provided by its agent, and/or to propose annotations judged as appropriate according to a given interpretation focus.

Annotation supports the co-interpretation based on a structural coupling in two dimensions. Firstly, the interpretation via annotation is “enacted” by agents in the way that they recreate the meaning in their own world of meaning following the interpretation process presented in section 1. Secondly, interactions through annotations preserve the interpretation autonomy of each agent and thus allow establishing the expected “structural coupling”

4. CATS: Collaborative Annotation of Time Series

The CATS system has been developed to support the interpretation by clinicians of time series data (Records of patients in intensive care units). The system autonomously performs the interpretation and interacts with the clinician via annotations.
4.1. Time series data interpretation

The interpretation of time series data consists in extracting significant events and scenarios (events combinations). Based on these significant entities we use three annotation types:

- segments that delineates interesting parts of time series,
- symbols that associates segments to events,
- relations between symbols to annotate time series with scenarios.

For mutual understanding, the semiotic content of our annotations is reduced to the minimum. In particular, there is no textual content that a machine can not appropriate.

4.2. Global view of patient records co-interpretation process

![Figure 1: Global view of the interpretation process.](image)

The figure 1 illustrates the global view of the co-interpretation process. The clinician annotates a patient record to interpret the clinical case. The interpretation is situated by contextual information that describes the patient pathology, etc. At the same time, the system builds its models from clinicians annotations and performs automatic annotations on the same patient record (co-interpretation). In exchange, machine models and annotations allow the clinician to refine its own knowledge.

Moreover, the machine performs in parallel large scale annotation of all patient records. Then, machine difficulties or new features identified are reported to the clinician for future situated patient records co-interpretations.

4.3. Autonomous system description

The CATS System autonomously performs the interpretation of the time series across four successive abstraction levels: time series, segmented time series, symbolic time series and situations (record annotated with scenarios). In parallel, the system builds models of events and scenarios. The models constitute the knowledge acquired by the machine along the interpretation and are used to perform the annotations. Consequently, the machine annotation evolves according to its “experience”. Some feedback processes make consistent the new acquired meaning and the knowledge and thus simulate the appropriation of the meaning by the machine. More details about the system can be found in [6].

Due to feedbacks processes and dynamic insertions of annotations by the human, the knowledge construction is a highly dynamic process. Therefore, CATS is a multi-agents system. Agents dedicated to each processing step have been constructed:

- Segmentation agents perform the segmentation. Each agent embed an event model and browses time series to find patterns that match its model and then annotates the time series with the corresponding segments.
- Classification agent collects segments and classifies them. Classes of segments are identified with events and in a second step, the classification agent translates segments in symbols. The symbolic name of a symbol is associated with an event.
- Learning agents collect the resulting symbolic time series. Each agent aims to explain occurrences of an event. The explanation is a scenario learned using a APriori-like algorithm [5]. In a second step, the agent performs scenario recognition to annotate time series with situations.

4.4. Processing example

The figure 2 illustrates a co-interpretation of time-series via segment and symbols annotations. (a) Two annotations (horizontal bar) are inserted on the signal by the clinician to indicate asynchrony periods. (b): Annotation completion by the system: dark-gray boxes indicate retrieved asynchrony periods. Medium-gray boxes indicate retrieved non-asynchrony periods (shorter than asynchrony). (c) The clinician has annotated the unrecognized segments. (d) A new model for new periods has been discovered (single light-gray box), the “asynchrony” model has been refined to retrieve all asynchrony periods.

5. Evaluation strategy

Our evaluation framework is based on three levels: feasibility, performance and usability. Because we propose a new approach for collaboration, we should evaluate its feasibility. Feasibility means that our implemented system: 1) provides an effective structural cou-
pling collaboration preserving the autonomy and adaptability properties of the system. Its capabilities for models construction, models emergence and automatic annotation should be highlighted; and 2) shows interesting characteristics compare to other collaborative approach.

For time series data exploration, the system performances can be assessed considering three aspects: (1) the capability to efficiently explore and annotate a large amount of time series data, (2) the quality of the built computerized models of events and scenarios, (3) the capability of new events and scenarios discovery. With simulated data sets, objective measures of quality can be proposed. Then, we can compare performances between a fully, partial or absent collaboration with various systems.

The usability evaluation includes human-machine interaction criteria and cognitive science criteria (work load evaluation, result confidence, etc.). It requires the use of interviews and questionnaires to gather experiment feedbacks. In term of acceptability by the users, the adequacy of the collaboration in the clinical environment and gains compared to the standard practice should be evaluated via clinical trials.

6. Conclusions and perspectives

Structural coupling and Enaction theory appears to be a new interesting approach for the collaborative interpretation of time series data. In particular, they lead us to cope with the mutual understanding issue with exchanges of annotations. Annotation seems to us an support of co-interpretation in the sense that it allow preserving autonomy of each interpreter and facilitate the appropriation of the co-constructed interpretation of time series.

The perspective of this work is the evaluation of our CATS system constructed on autonomous annotation and evolution principles.

References


ENACTIVE/07