Co-constructing Subjective Narratives for Understanding Interactive Simulation Sessions

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Abstract

Stories are used by human beings to transmit knowledge, explain events, and generally make sense of the world. Creating a narrative is then considered as an activity producing meaning, allowing the narrator to formulate causal relations between selected events. Through the act of telling a story, the narrator makes explicit their own understanding of a given situation.

In this paper, we describe an ongoing project, based on an existing simulation-based training software. We are creating a set of tools allowing users of such software to make sense of what happened during the simulation from their point of view. Based on previous work allowing to represent the causal flow of events formalized as actions, we describe the current issues we tackle for providing a tool helping users to describe their own view of what happened. In addition to helping with reflection about the training session, such a tool has the potential to support learning by allowing to contrast different points of view during pedagogical activities such as cooperative learning or tutored debriefing.

1 Introduction

Simulation Training is a form of experiential pedagogy, considered as particularly effective. It may be underpinned by software (the family of serious games, or useful games dedicated to learning), and associated with a debriefing session allowing the participants to understand what has happened during training [FG07]. This allows a safe and cost-effective solution where participants learn from the actions they performed during the simulation.

Military Training often relies on a simulation whether it occurs at a sophisticated instrumented range, in a collective training simulator system, or in a command and staff exercise using a mathematical model driven war game. Training occurs in live, virtual, constructive, or mixed simulations of battlefield environments. In the live environment, units use operational equipment and actual terrain to perform against an opposition force composed of military personnel (live force-on-force) or targets (live fire). In virtual environments, units use simulators to represent equipment and weapons. Weapon effects, terrain and enemy forces are computer generated. In constructive environments, battlefield outcomes are

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determined by a computer simulation in order to provide battle effects supporting command and staff training. Training in all of these simulation environments should provide individuals and units with feedback about how their actions contributed to mission success or failure.

Broadly speaking, a training session starts with a phase of *preparation*, where the realistic operational environment is created, followed by a phase of *exercise* where all the participants take part in the simulation and, finally, a phase of *debriefing* where the players have an interactive discussion (guided by a moderator) in order to understand what happened during the training and why, as well as how to improve or sustain performance in similar situations in the future. Duration and timing of the discussion [AS94] are very important: too many details lead to a lack of concentration among the participants, and inadequate timing tends to make them forget the reasons behind them taking a specific course of actions.

The large amount of data generated during training complicates this task [1]. To alleviate this, we propose to develop a narrative creation toolkit for assisting human-made explanations, in terms of a story (or narrative), of a given simulation session, to all the participants involved in it. The idea is to provide a semi-automated analysis of the course of the simulation-based narrative reconstruction of the (potential) causal links that exist between the events that occurred in the simulation, and tools to support their structured presentation. *Causal graphs* in the tradition of [Pea09] will then be integrated to the war game replay interface by a system of *vignettes* that provides the participants with useful information for explaining a given situation which occurred during the simulation.

2 Narrative debriefing for simulation-based training

Humans have always used stories to make sense of the world and explain the unfolding of past events. A number of technology enhanced learning approaches have therefore naturally adopted narrative-based pedagogy [DP09]. In such an approach, telling a story entails formulating causal relationships between selected events [vdBvOPV08, Abo10]. In the field of education or serious games, *storification* [AAH09] is used to describe the creation of a causal structure by establishing links between narrative events. One of the challenges in these areas is the realization of systems to automate or semi-automate this activity in order to educate various user profiles. Conversely, studies in psychology of story understanding have also shown the importance of the perception of causal relationships between narrative events [TS85].

While modeling causality occupies a central place in Artificial Intelligence (AI) [Pea09], Narrative Intelligence's point of view is closer to *commonsense reasoning*: the narrator must select the events to be told, express the causal links among them and select a level of granularity of such connections in order to make the final story meaningful. Contrary to classical approaches from AI, narrative intelligence attempts to provide an explanation in a form that is presumably more understandable for a human user [Rie16].

Our aim is not to provide a fully automated story construction system such as in recent machine learning approaches: our system must support the confrontation of different points of view during debriefing and cooperative learning activities. As such, it should help each user to construct and explain their own subjective narrative, depending on the information they had access to (depending on the roles of the participants this may widely vary) and their decision rationale. The tutor in charge will have access to all information and their constructed narrative will be different as well.

3 A Linear Logic based approach to story construction and analysis

The formalisation of narratives is a problem that has often been approached in Artificial Intelligence from the perspective of *Knowledge representation* and *Reasoning about Action and Change* (RAC), starting from the atomic modelling of a narrative action, and describing its impact on the environment. Authors of [BCC10, BCFC11] use *Linear Logic* [Gir87a] for the modelling, which has led to formal approaches to story analysis and property verification. Among other advantages, this approach allows to model in a declarative way each event, by describing its impact on the environment in terms of consumption and production of resources. This has led to systems where stories generated from a linear-logic based declarative specification could be described by reconstructing causal relationships between events and displayed in terms of causal diagrams [MBFC13, MFBC14].

Building on these previous work, we propose to extend these formalisms in order to cope with two important aspects of human understanding from the perspective of narrative analysis: the exploration of *counterfactuals*, and the *granularity of causality*.

- **Counterfactuals:** from a psychological perspective, *counterfactual reasoning* is the mental simulation of alternative scenarios of the type "what if ...", where the invalidation of one or more events leads to the deduction of an alternative reality, which plays a central role in the judgement of causality associated to a set of events [Maz04]. In AI,

[1] A short simulation may imply the generation of approximately 60000 messages

counterfactual reasoning was first formalised by D. Lewis [Lew73], who provided a clear semantics based on *spheres* leading to a great deal of results in argumentation [Sak14], causality [Ort99] and hypothetical reasoning [Hal99]. The problem has been recently revisited in [BBG18] where a novel formalisation in *Answer Set Programming* [BET11] is provided. Exploring counterfactual scenarios entails analysing variants produced by the simulation in the *replay* mode available in the tool.

- **Granularity:** the relationship between the number of causal relationships on a set of events and the importance of perceiving an event in a story has been widely developed in [Maz04, TvdB85, TS85]. Based on these contributions, we expect to develop heuristics that work on a predefined narrative structure. Those heuristics would allow, at least, the assisted construction of a well-formed story that explains a given situation. Other heuristics based on domain-specific knowledge as well as interaction patterns between the various actors of the simulation are also being explored.

We are currently working on identifying complex events as well as higher level actions and their possible decomposition[2]

4 A constructive simulation for military training

The training software we use relies on a constructive simulation which allows us to engage brigade and division command staff in large-scale conflict scenarios such as stabilisation operations, terrorist threats or natural disasters. It simulates a diverse range of situations in realistic environments and lets trainees lead thousands of autonomous subordinate units (at platoon and company levels) on the virtual field. Agents can receive operation orders and execute them without additional input from the players, while adapting their behavior accordingly as the situation evolves.

Models capturing such behaviors consist of two components: the algorithms that make agents perceive, move, communicate and shoot, and the description of the capabilities of the underlying equipment stored in a database. The simulation session database contains three different types of information:

- **The data regarding the physical element:** Constitutions of the units are described here. Because the simulation is constructive, most of the features of the equipment or units are described by their effects or their capacities. This facilitates their description in terms of action and change.
- **The initialization data for the scenario** containing the following information: terrain, order of battle, weather, data provided by the simulation such as events, knowledge obtained by the agents, etc.
- **The data generated by the simulation describing the evolution of the situation:** information describing the evolution of the game containing all events, knowledge about the environment and all mission reports.

All this information is presented to the participants as a set of messages exchanged among the agents during the simulation that contains all the information described above. We show an extract of the simulation below:

```
[07:29:47] - Report - ENG.Counter mobility platoon: Disembarkment
              started
.....
[07:30:17] - Report - INF.Mortar troop: Unit detected at ...
.....
[07:30:17] - Report - INF.Rifle platoon: Unit detected at ...
```

Once the initialisation data, the elements of the simulation, and the report messages are translated into formal action description, a raw analysis in the fashion of [MBFC13] is constructed. Visualization tools must then be developed to support human explanation. The training software we use is equipped with a *replay* function which we intend to improve with narrative content. Traditional military Command&Control tools are a suitable starting point (map layers overlaid with specific symbology), but to *make* sense, certain points of view must be chosen for each node in order to understand each situation and their relationships. We propose to build *Vignettes* to represent the most salient nodes of the narrative graph.[3]

This can provide an analysis of the current maneuver in order to :

1. replace the operator in the current situation and explain the current maneuver;
2. propose an automatic synthesis of the tactical situation. It can be the calculation of the current force ratio or simply a realistic view of the geographic capacities of units (fire, intelligence, etc.) and illustrate a bad use of the forces on the field.

[2]Work on higher task decomposition has been considered in [HPX16].

[3]The selection of the important nodes of the graph will be done via a mixed-initiative strategy involving automated scoring and user input.

3. calculate and alter the consequences of specific events . For example, calculating the delay for logistical units or support units after a *bridge broken* event.

Figure 1 presents examples of a vignettes representing delays and capabilities for some unit to support some other units.

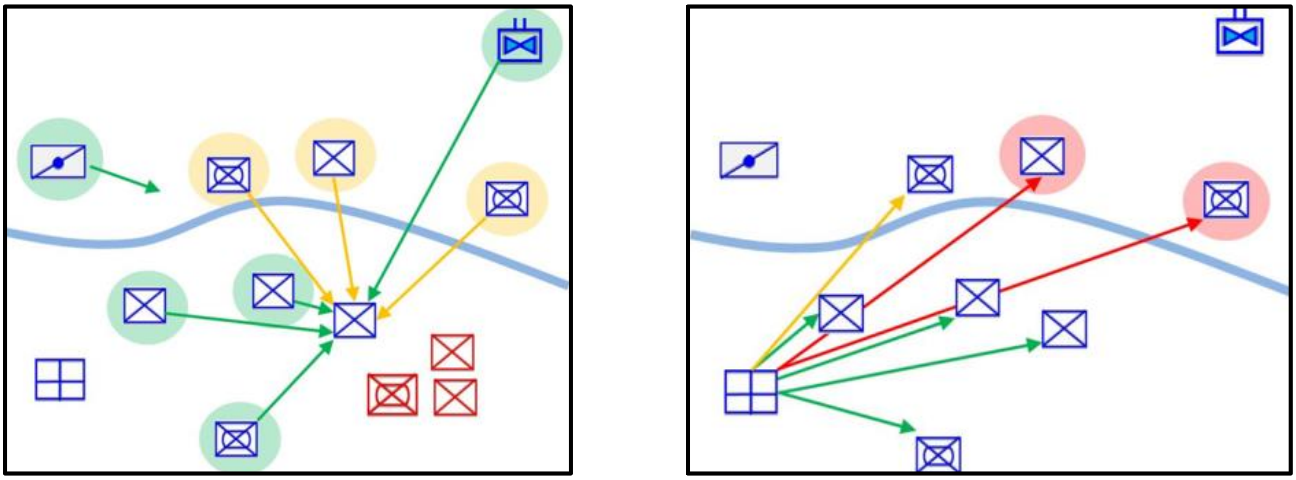

Figure 1: Many-to-one fire-support capabilities toward the central blue unit against the red units (left). One-to-many support capabilities of the lower left unit toward other friendly units (right). On these vignettes, timely and effective support capability is color-coded: from good (green) to poor (red). We use *NATO Joint Military Symbology* as defined in [Nat14]

5 Related work

In a position paper, Niehaus et al. [NYR+17] point out the use of narrative intelligence for sensemaking as a promising line of research with potential application in several scenarios such as military, health-care or business intelligence. They propose a machine learning-based approach that takes into account the narrative structure as well as the causal links among the different events of the story.

The *Bardic* [BBCR+17] system uses *narrativisations* to describe the activity in complex domains in such a way that the information becomes accessible to non-experts. This system translates a given log file into a first-order logical theory expressed in Impulse [EBY15][4] and, from this representation, the system is able to obtain a causal graph by analysing all action preconditions with their corresponding effects.

Our proposal differs from [NYR+17] in the approach: we want the participants in the simulation to be able to author (with assistance) what happened from their point of view, so whilst we plan to incorporate some localised supervised learning to facilitate repetitive tasks, we are not looking for a fully automated machine learning based storyfication system. With regards to the work reported in [BBCR+17], we find several similarities with the Bardic system : both systems are supported by a logical formalism (In our case, we use a resource-based encoding of linear logic [Gir87b]) and both tools are oriented towards the extraction of causal information from a source of data. However, the way such an extraction is obtained differs: Bardic uses a STRIPS-based approach [FN71]. We work from an expressive logical formalism for representing actions in Linear Logic, and plan to further explore the use of counterfactual causality [Lew73].

6 Conclusions and future work

In this paper we presented a research project relying on the use of logical tools for debriefing in simulation-based scenarios. We base our work on previous approaches relying on the use of Linear Logic-based formalisms, and intend to exploit counterfactual reasoning for allowing the co-construction of a causal graph that explains a given simulation by the user and a narrative assistant. Finally, in order to display the causal information, we propose an interface based on vignettes.

We would like to remark that the use of a logical formalism for the narrative representation allows us to isolate the kernel of our approach, and to apply it, modulo minimal changes, in a variety of simulation based training environments.

[4]Impulse is a first-order temporal-epistemic framework for describing narratives that allows expressing temporal properties by means of Allen's relations [All83] as well as epistemic information of the characters thanks to the use of epistemic modalities [vDHvdHK15].

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