Context-based modelling for nanny decision-making

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Abstract

This paper presents a formalisation of context for use in real-world applications in coordination with concepts coming from Cognitive Sciences. Our AI approach is centred on the modeling actor's experience for accomplishing an activity in different contexts. An actor develops each time a mental model as an operational explanation in a specific context of an activity, and concretises experience in a mental representation containing all the mental models created in the different contexts where the activity was realised. The approach is based on activity modeling in a referential at four levels, namely conceptual, operational, implementation and environment levels. The Contextual-Graphs (CxG) formalism, which achieves the four components of the approach for one actor activity (CxG_1.0 version) and for group activity (CxG_2.0 version). The resulting software offers a new vision of context as proceduralised context leading to a definition of realtime context and to a CxG-based simulation tool for following contextual reasoning during activity development, especially collaborative activity. The application, on the Anam Cara Ontology project, is based on the interactions of nannies with their Anam Caras (soul friends) illustrates the different aspects of the CxG formalism.

Keywords: AI systems, decision-making, activity, mental model, contextual reasoning, contextual-graphs

1 Introduction

In living sciences, the scientific approach for developing knowledge aims to formalise concepts by confrontation of a model to observable phenomena of a real system (Brézillon 1983). It is called a hypothetical-deductive approach with an inductive complement when the model fails to explain observable phenomena: the ideas need to be revised and the model improved. We adapt this scientific approach for modelling in AI how an actor carries out an activity in a given situation with a local environment and the needed resources for the realiSation of the activity (Brézillon, to appear). Such conditions constitute the context of the activity.

Our approach is based on a modelling of actor's activity at four levels, namely, conceptual, operational, implementation and environment levels. We also consider activity modelling carried out by a group of actors by extending the framework used for one actor activity. A context-based formalism of representation plays an important role of "concept reveler" in an activity model at different levels from concepts to an operational model and finally to an implementation to be fed at to context sources in activity environment. Reasoning is defined in various disciplines (more or less formal) along different priorities: formal exploration of logical rules, psychological mechanisms, or even practical applications. Reasoning consists of starting from collecting, assembling and structuring contextual knowledge and information for making a valid decision that maximises the means to use for a given goal. Thus, decision-making being central in activities.

Section 2 presents our approach for modeling actor activity at four levels, from the more abstract to the more concrete one, starting from concepts used in our modeling with refinement of the concepts at the lower levels. Section 3 presents group-activity modelilng as an extension of the actor-activity infrastructure. Section 4 illustrates the possibilities of the CxG formalism on the example of « Nanny-Anam Cara interactions ». Section 5 presents close works related to our approach, and Section 6 concludes by showing an opening for other research on this topic and for merging the CxG formalism with new promising ways.

2 Modeling levels for actor activity

2.1 Introduction

The general framework for modelilng actor activity is presented in (Brézillon, to appear), we give here only few characteristics. There are four modelling levels are (1) the conceptual level where ideas are stated on the basis of concepts of interest for modelling an activity, (2) the operational level where ideas are formalized in a mental model, thanks to a relevant context-based formalism of representation, (3) the implementation level where mental representation of the actor is expressed in a contextual graph from where is extracted the mental model, as a path and (4) the environment level where the model, first, interacts with the activity environment (and mainly actor as source of context), and, second, from where contextual elements are instantiated when needed from the four context sources. In this framework, the activity model exists jointly at the operational level (actor's understanding of the activity as a mental model) and at the implementation level (a sharable understanding of the activity development in its environment as a path in a contextual graph), while the fourth level concerns environment. Operational and implementation levels represent two views on actor's experience (as mental representation and as contextual graph) on the development of a mental model from the mental representation.

2.2 Conceptual level

The conceptual level concerns the concepts "activity", "reasoning", "context", "contextual element" and "experience", these concepts of interest being not (at least totally) formalized. Our goal is to propose a formalisation of "context" in order to have an efficient formalism for modeling the other concepts of interest. We adhere to the definition of Sarrazin et al. (1996): "an activity is the (physical and mental) behaviour that an actor exhibits for realizsng a task". The notion of activity encompasses that of "task realisation" including actor that accomplishes the task. Modeling an activity involves modelling reasoning to justify the move from a step to the next one. As a consequence, an actor apprehends an activity through a mental model including its development (reasoning steps with processes and decision holds at each move between steps). At the end of each activity step, the next step is chosen by either a deductive (i.e. sequential) reasoning or contextual knowledge if there are alternatives.

Decision-making, as an operational representation of reasoning, often is described as the process of collecting, assembling and structuring the relevant knowledge and information to contextualise the decision for action. Reasoning is a cognitive process that underlies and guides the activity, and the actor is part of the context-based modeling loop.

Context allows distinguishing contextual knowledge and external knowledge concerning activity development. Contextual knowledge is the set of elements related in a flat way to activity development, while external knowledge concerns elements of the context that are not important for the actor's focus at hand. Context changing during activity development, the frontier between the two types of knowledge is porous. An element of contextual knowledge can become external if it is no more of interest, and, conversely, an element of external knowledge can become contextual because considered for the development of the activity.

2.3 Operational level

The concepts chosen at the conceptual level acquire a more efficient expression though a context-based formalism at the operational level. We also retained from Cognitive Sciences the notions of mental representation and mental models, but with a different interpretation on the relationships between them. An activity is more than a task model, because it integrates how the task is realized and actor's reasoning held. The context-based formalism provides an expression of actor's experience as a mental representation that brings together all activity developments made in different contexts. For simplifying the introduction of context from different sources in activity modelling, we assimilate context to a set of contextual elements. A mental model is an internal representation of external reality (Craik, 1943) to anticipate events, and a mental representation results of the accumulation of mental models obtained in different contexts. An actor, facing a known activity, does not seek to have a global picture of the activity but wants to follow step-by-step the reasoning to detect if all elementary decisions were justified in the context at hand or how a reasoning step must be changed.

The actor develops a mental model based on identification of the relevant contextual elements and the recovery of their instantiations in the context at hand. Identification and instantiation of contextual elements are part of reasoning from one step to the next one. This step-by-step evolution of the activity produces an ordered sequence of instantiated contextual elements that we call hereafter the proceduralised context. Proceduralised-context building, first part of decision-making, concerns the gathering, assembling and structuring of instantiated contextual elements. The proceduralised context expresses a real-time context, which evolves jointly with the mental model development.

2.4 Implementation level

Mental model and mental representation correspond to a qualitative modeling that makes sense mainly for the actor but need to be implemented to be confront to the environment and shared with others. The CxG formalism allows a uniform representation of knowledge, reasoning and context for describing an activity as a process, not as object (Brézillon, 2023). A contextual element is implemented as a pair of contextual and recombination nodes (Brézillon et al. 2000). This definition has a deep impact on the power of the CxG formalism. Figure 1 shows the four components of the CxG formalism that are action, contextual element, activity, and Executive Structure of Independent Activities (ESIA).

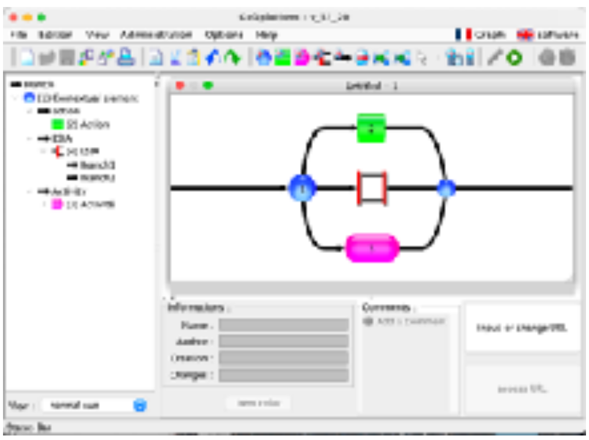


Figure 1 Components of CxG formalism in the CxG software

An action (the green square) is the elementary component of the activity. Contextual elements (the blue circles) are described just below. An activity (pink elongated oval) is a contextual subgraph that may appear on several paths in the global contextual graph or introduced by the actor for different types of knowledge. An ESIA (the vertical red bars) avoids the introduction of an artificial complexity in the representation for a local goal. The order for executing independent activities in an ESIA does not matter (activities can be executed in parallel too), but both independent activities must be executed before to continue the crossing of the contextual graph. An ESIA also is assimilated to as a building block of the CxG formalism, like an action or an activity, because its content is isolated of the rest of the activity described in the contextual graph. Note that we will not use activity and ESIA in the example given hereafter.

CxG software[1] is currently written in Java under GNU Public License and contextual graphs are stored in XML for a reuse in other applications. Software design and development was user-centred for an intuitive use by nonspecialists in computer science and mathematics (see Brézillon (to appear) for an extended presentation). A contextual graph integrates mental models because two mental models generally differs by only different instantiations of an existing contextual element that do not affect the structure of the contextual graph, or by an additional contextual element in one mental model by simple accommodation.

The implementation of a contextual element as a pair of contextual and recombination nodes in the contextual graph offers functions that enlarge the operational nature of the modeling:

- There are as many exclusive branches between a pair of nodes as instantiations of the contextual element.
- Instantiations are provided from sources of context at the environment level.
- Each branch corresponds to an expression of the reasoning step associated with the instantiation and makes the mental model unique.
- contextual elements and instantiations must be managed separately.
- Two contextual elements are either independent or one is on a branch of the other. it gives to contextual graphs a series-parallel structure.

2.5 Environment level

The immediate environment of an activity is all that is not in the activity but constrains its development. The two elements at this level are the sources of context and the instantiation of a contextual element. The four sources come from the actor, the activity, the situation and the available resources needed in the local environment. They provide in routine the instantiations for contextual elements on the path followed in the contextual graph. Actors play a central role in activity modeling because knowledge in a contextual graph is mental representation and experience of the actor. Moreover, the actor is responsible for fixing unexpected situations. First, the mental model is correct, but its context is new for the actor and thus not in the contextual graph. Second, a contextual element is missing in the model because it kept the same instantiation in all previous contexts (the constant instantiation is integrated in the activity before the development). Third, the

[1] The software is available freely from the author on simple request.

activity must be performed in a radically different context that requires an extension of the activity model.

For efficient decision-making, actors seek first to identify the context at hand to determine the sequence of actions to realise and act rapidly. The context of a mental model can be analysed by unfolding the proceduralized context, and the “what to do” is provided by the list of actions to execute.

Garcia and Brézillon (2018) proposed a tree representation of an activity model, based on the series-parallel structure of contextual graphs, to interpret a mental model more easily than the graph representation. In this tree representation, the tree corresponds to the mental representation, and each branch corresponds to a mental model. Thus, mental models present two parts: diagnosis and action. Diagnosis part is the proceduralised context, and action part contains the “macro action” corresponding to this specific context. In several domains, operators reason first on the context of the problem to fix, and, second, prepare their decision -making according to the context.

3 Extension of the CxG formalism to group activity

3.1 Formal aspects

A group activity is a sequence of individual interventions of actors, interventions being considered as independent subtasks. As a consequence, the activity of each actor becomes a set of independent subtasks in the group activity, and group mental model must be built as a sequence of actors' interventions). Building a group mental model consist of adding an actor's independent subtask at the end of the sequence of previous independent subtasks already built and assembled, once the last subtask has its contextual elements instantiated. This double operation of building and developing the group mental model is managed by reserved contextual elements that controls the cyclic use of the directed acyclic contextual graph by determining which actor (net manager) has to take in charge the next cycle and for which independent subtask (marked as task_status). The cyclic use of the directed contextual graph (at implementation level) relies on the concepts of turn (the crossing of the contextual graph for developing an independent subtask) and shared context (transfer of information between turns). Figure 2 presents the four-modelilng level framework description (extension of previous one).

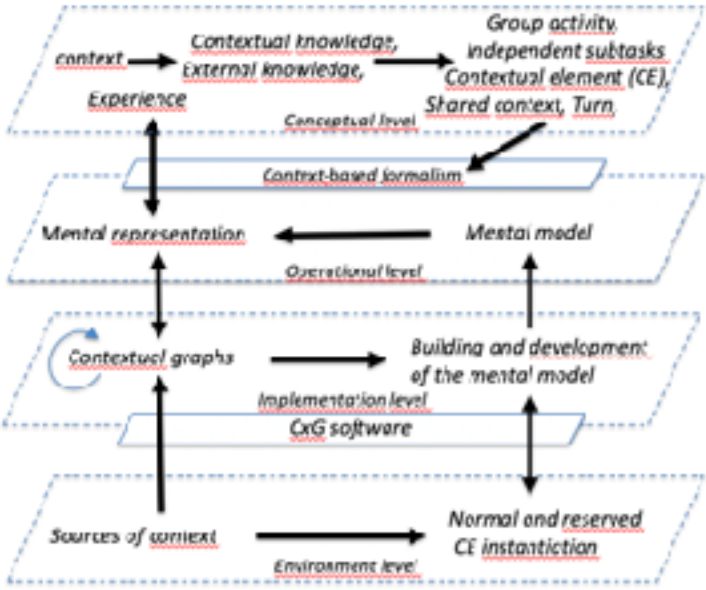


Figure 2 Group activity at the four modelilng levels

The cyclic use of a contextual graph is concretised on figure 2 at implementation level by the rounded arrow at the head of the word “Contextual graphs”. Mental-model building results of the paths used in a cyclic way in the contextual graph. At operational level, the arrow from mental model to mental representation on figure 2 points out the fact that, once built, the mental model could enrich the group mental representation. Reserved contextual elements are manager, sender, recipient and task_status. The manager is the actor that executes an independent subtask on request of a sender, the independent subtask being identified by task_status and transmitted to recipient. The contextual graph is organised for supporting turns with (1) selection of a manager (instantiated by an actor) for realising an intervention, (2) selection of an independent subtask in manager’s activity to perform, (3) the designation of the next manager and its independent subtask to execute at the next turn. As such, a sequence of turns constitutes a CxG-based simulation.

The shared context contains the previous results, normal and reserved contextual elements that the manager can access during each turn. A new turn starts if the shared context has been modified during the previous turn. The contextual node, which is the input of the contextual element, is presented as a question, for example “MANAGER?”, “TASK_STATUS?”, and the instantiation corresponds to one answer to the question and is associated with an independent subtask on the corresponding branch between contextual and recombination nodes. Instantiation is specified by an action like « MANAGER = anam cara » at the end of the previous turn. If no instantiation is indicated, the value “nil” is taken by default, and the activity development will be stopped. During cyclic use of a contextual graph, shared context plays the role of an inference engine for managing the CxG-based simulation of the the group-activity development. The shared context is the medium of communication among actors on the current state of the group activity when its development moves from one actor to another one. Shared context emerges out of interactions and experiences among group actors. The turn-by-turn building of a mental model offers the possibility to redo a turn for analyzing the intervention of an actor in a different context in a kind of “what if” search. The shared context opens the door to more options like (Garcia and Brézillon 2018):

- The simulation can be stopped at the end of any turn (with “RECIPIENT = <nil>”).
- Reserved contextual elements control the management of conflict, negotiation, alternative checking among actors and realisation of a given subtask in different contexts.
- An actor can change the objective of an actor when an unexpected event occurs (e.g., a selected object is not adapted to the objective), allowing backtracking in one actor's reasoning or the group.

- The same activity can be given to several actors (e.g., reviewers in submission management).
- An independent subtask may have different outputs that make reasoning nonlinear.
- Independent subtasks can be reused in different combinations and several times with a unique implementation, thanks to the separation of contextual element and instantiation.
- An actor may change the instantiation of a contextual element that is used in a subtask of another actor (or several other actors).

Making explicit the shared context allows to follow the reasoning held during a group activity and thus to have an explainable CxG-based simulation of the group-activity development.

4 The « Nanny-Anam Cara interactions » example

Everyone knows the situation in which we face a problem for which we face two exclusive solutions, first doing as usual, and, second, accept a radical change with unknown results for us. For example, in the model discussed in this paper, a nanny receive an offer from a family to take care of their baby during the post-partum time of the mother once the baby is born and parents are away of their home. The activity of the nanny is baby care, but also mother training for baby care and management of different social influences like family and religion. The task cannot be automated because the human dimension play a major role, and the way in which the task is realised (the nanny activity) may become challenging for the nanny if a decision-making may have severe consequences for the nanny: she must ensure the mission even if this leads to an opposition with a close third party, but also if an unexpected event require an immediate attention. It could be a trap for a nanny in the mental-model built for her activity.

In a situation of radical change, nanny's feeling is to have not the crucial information about her ability to assume the position, and looks for a support for enriching her context of the situation for making the right decision. Generally, support comes after a triggering event, a person that manifest an empathy for the nanny, either a close person like the grandmother of the baby or an external person. In Psychology, such a person, which is called Anam Cara (soul friend in the Irish story), and the nanny establish a shared context within human consciousness that gives access to this world through its operations (Bedi et al., 2026).

An anam cara only advises or suggests the actor on mental-model building for avoiding the trap. In the CxG formalism, the contextual graph corresponds to the mental representation (the sum of the mental models developed by the actor), and a mental model is a path in the contextual graph. Based on her experience with other actors, the anam cara's intervention concerns the co-management of contextual elements and their instantiations in the mental model for a "problem to be fixed » of the nanny. The anam cara encourages the nanny, based on the shared context, to overcome the trap the nanny might otherwise never have crossed on her own. The encouraging presence of the anam cara would be like the truest mirror for the nanny to change of mental model to fix the problem by modifying her line of reasoning by proposing new contextual elements, or simply different instantiations of known contextual element.

The context-based modelilng of actor-Anam Cara interaction is realized in the CxG_2.0 version of the CxG formalism (Brézillon, 2023). The modeling is inspired of an experiment for supporting nannies in Hong Kong who have an offer from a family for taking in charge their new born/young children because the parents are away of their home most of the days (Luk 2026). Nanny stays at home for 8 hours a day during 30 to 45 days (post-partum time) once baby born. Employment period being short (less than two months), the nanny is unlikely to play an anam-cara with the child, which is the role of the mother, but to sustain relationships of the mother with the baby. Nanny activity has several aspects to manage baby care, a role of anam cara for the mother, the contact for the immediate family (husband, siblings of the baby and of the parents, and grandparents) and control social influences that may put pressure on baby care, directly or indirectly through the mother like family tradition and religion. However, the mandatory rule for the nanny is to follow parents' instructions and keep inform them.

Thus, saying YES to parents' offer are supposed to assist working parents to release from pressures on baby caring and help the mother in post-partum with a good caring for speedy recovery. However, contextual factors for deciding to accept the offer of parents may block the nanny to say yes. HK nannies need to feel confident in their ability to "saying YES” and to be sure to sustain their self-love in challenging contexts in very different living and environmental conditions nannies know. Nannies may need an anam cara for helping them to make the right decision in different contexts before to say YES.

The accomplishment of nanny’s activity « solving the problem to be fixed » may move to a new shared context that, once proceduralised, will contain the needed explanations on the problem solving. The anam cara, with an external viewpoint, can guide the nanny to have this type of introspection by putting on the table all the sensible contextual elements--especially those left implicit in the proceduralised context--to propose the nanny another instantiation possible or not, and thus enrich the contextual graph, allow the mental-model accomplishment, and reinforce the self-confident of the nanny.

The nanny has, at least, the elementary competences and skills. Thus, any usual problem occurring in the activity is part of the competences and skills of the nanny. Traps occur when a source of power is in conflict with nanny’s mission. Identify the « sources of power » at the first discussion with parents is important as well as parents’ position on the problem. An anam cara can help the nanny on such conflictual situations. The nanny must always follow the parents’ instructions, not the grandparents’, unless the parents have explicitly delegated authority. For example, medication, medical appointments, daily care are stipulated by parents, not grandparents. Nanny’s attitude must stay respectful (no direct conflict with grandparents, firm but polite (I’m following what Mom and Dad asked me to do), neutral (not taking sides, just applying parental rules), transparent (informing parents if grandparents tried to override their decisions).

On these basis, we are modelling nanny’s mental representation of her activity in a contextual graph, knowing that mental-model development in a specific context is a path in the contextual graph. The cyclic use of the contextual graph allows to manage successive questions between the anam cara and the nanny, leading to modify the context of the trap for YES (and eventually fixing rules to respect). A complete model will be developed later. The nanny example is based on five classes of contextual elements (personal, activity, situation, social aspects, practical aspects) as established in the study of the analysis of an internship offer by students (Brézillon, to appear). The goal is to model the problem solving (the trap) that appear in these classes, not directly the activity itself. For example, the trap can be a conflict with a referent and the nanny then has another problem of loss of motivation. In that sense, the model focussing on trap solving is a behavioral model of the nanny.

The crossing of the contextual graph represents the reasoning held by the nanny that follows a path in the graph, that is, the proceduralized context (the ordered sequence of instantiated contextual elements). Reserved contextual element "task_status" is an accumulation of traps, mood being a contextual element instantiated to « bad ». A crossing of the contextual graph corresponds to a reasoning step held by the nanny. For example, after questioning (personal class), the next nanny's reasoning step explains that there is a conflict with an external referent. The cyclic use of the contextual graph offers the opportunity to develop a reasoning (personal or collective) step by step. The collective reasoning (anam cara and nanny) is developed during interactions until the shared context stops to be modified.

On figure 3, the contextual graph represents contextual elements organised in the initial classes (personal, situation, activity, social aspects, practical aspects), and only the nanny part is (very partially) developed. Green square boxes represent actions (sentences in this application like « I have the feeling of pressure with different aspects » in action 143). Light brown squares represent the instantiation of reserved contextual elements (in capital letters). The blue circles represent contextual elements that need to be instantiated. The crossing of the contextual graph corresponds to the execution of an independent task by either the nanny or the anam cara, although that now this part is not yet developed for the anam cara. The series of crossings constitutes a CxG-based simulation (see figure 4).

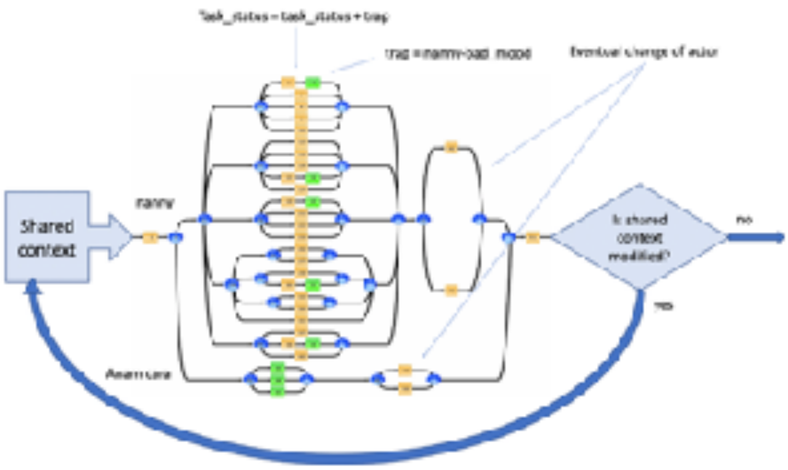


Figure 3 Contextual Graph for Nanny-Anam Cara interactions

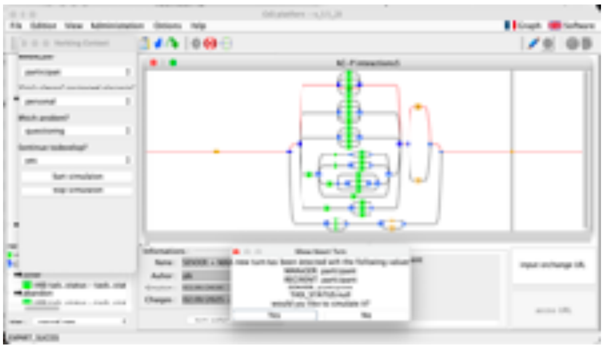
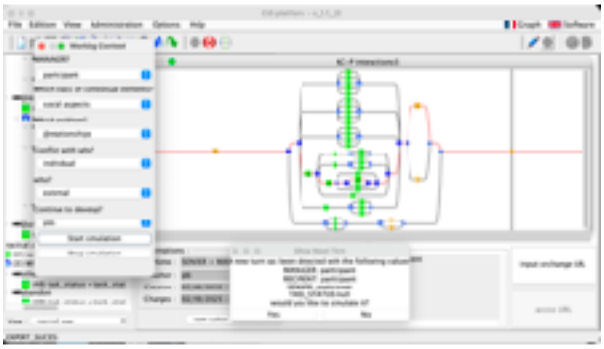
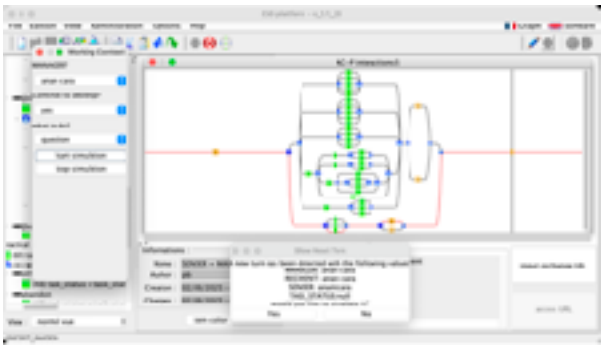
*********************** Simulation Trace ***********************	
Step 1 MANAGER? nanny Which class of contextual elements? personal Which problem? questioning task_status = task_status + personal-questionning Continue to develop? yes	
Step 2 MANAGER? nanny Which class of contextual elements? social aspects task_status = task_status + social Which problem? @relationships task_status = task_status + social-relationships Conflict with who? individual who? external task_status = task_status + social-relationships-individual-refer Continue to develop? yes	
Step 3 MANAGER? anam cara what to do? question ask question Continue to develop? yes	

Figure 4 A short simulation of the preliminary turns during Nanny-Anam Cara interactions

Figure 4 shows a specific exchange (three turns) between the nanny and the anam cara that can be followed in the trace of the simulation on figure 4. At the first step, the nanny states that she does not not feel comfortable, and has questions about the family. The next crossing (step 2) is triggered by the nanny for completing her first utterance (a conflict with an external referent), and step 3 is for the Anam Cara. In step 2, spontaneously the nanny completes her position by saying that the problem is with an external referent that the family respect the authority. The step 3 just indicates that the anam cara ask the nanny a question to clarify what the trap is exactly. Different types of interaction can be represented, completing an answer like in step 2, the nanny can come back on what she said after a comment of the anam cara, the goal of the exchanges being to lead the nanny to revise her initial judgment on the trap. The conversation can also concern technical points like what to look after when the baby does not seem well.

Moreover, the example illustrates two other important features of the CxG formalism, namely a real-time definition of context and a modelling of the contextual reasoning. The proceduralized context provides a structure on the evolution of the interactions than can be « replay » later, thanks to its representation as an ordered sequences of instantiated contextual elements (with initially RECIPIENT = nanny). For example, context development during step 1 is described as:

> MANAGER(Nanny) - Class—contextual_elements(personal) - Personal problem(questioning) - [actions] - Continue_to_develop(yes) - RECIPIENT(nanny)

It is also possible to model contextual reasoning by adding to the proceduralized context the action executed once a contextual element is instantiated:

> MANAGER(Nanny) - Class_contextual_elements(personal) - Personal problem(questioning) - TASK_STATUS(+personal-bad_mood) + Action 143 - Continue_to_develop(yes) - RECIPIENT(nanny)

In that sense, the proceduralised context appears as the real-time context and a context-based model of the contextual reasoning.

Another connection can be made with decision-making. Simon (1979) proposed a framework for describing decision-making process with four phases, intelligence, design, choice, review. This holistic view on decision-making can be reviewed in a concrete view in the CxG formalism where « intelligence » consists of the selection of the relevant contextual elements, « design » is the progress on a path in the contextual graph by the ordered instantiation of the contextual elements,

« choice » correspond to the elementary decision to make (either choice on the following contextual element to instantiate or the execution of an action), and « review » is to reflect the result of the local decision at the global level of the decision-making process.

5 Related works

There are very few works in the literature on modelling and use of context in real-world applications (see Brézillon, 2023, for an extended presentation). A reason is theoretical attempts to use existing tools like Logics in which context is considered as a first-class object. The two main schools were around John McCarthy (with later, Buvac), and Fausto Giunchiglia and his team in Trento (Italy). Main divergence with our research were different grounds for modeling context because their orientation toward logics is not directly concerned by modeling context in real-world applications. Nevertheless, two important findings of McCarthy (1993) resonate with ours:

(1) A context is always relative to another context with the corollary that context cannot be described completely because it has an infinite dimension;
(2) When several contexts occur in a discussion, there is a common context above all of them into which all terms and predicates can be lifted.

There are other pragmatic approaches like ours. For example, Dey (2001) and his team have a bottom-up approach of context-aware applications based on the context toolkit, not human activity (more top-down). The popular definition given by Dey is "Context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." It is easy to retrieve our four sources of context. The Context Toolkit contains a combination of features and abstractions to support context-aware application builders. The approach aims to acquire a certain type of context information (generally through sensors) and it makes that information available to applications in a generic manner, regardless of how it is actually sensed and modelled. Thus, the origin of context for Dey is more on data and information than on knowledge and reasoning as in our approach.

5. Conclusion

This scientific approach was applied over 25 years of research on how to model and use context in real-world applications on a spectrum from technology-centred to human-centric applications, that is, from well-defined domains to not formal ones, but all having the goal to model an activity. The presentation is discussed on the example “nanny - anam cara interactions” has all the necessary ingredients to explain the potentiality of the proposed approach.

Our research is part of an approach to designing and implementing AI systems that aim to understand actor(s) through their decisions, actions, and behaviours. Modelling actors’ experience was central to our research and led at a four-level framework: conceptual, operational, implementation and environment levels. For instance, contextual knowledge (conceptual level) is represented as contextual elements (operational level) and designed as a pair of contextual and recombination nodes (implementation level). The model of an activity has two sides, an operational one, on that an actor uses for accomplishing an activity based on a mental model drawn from his mental representation, and an implementation one, a contextual graph that can be used and readable by other actors. The focus of attention for modeling activity allows dividing separation of context in contextual knowledge and external knowledge. The explicit integration of context in the representation (through contextual elements and their instantiations) follows the human style of actors' activity (collecting and structuring information, making decisions, and acting). On the AI side, the CxG formalism of representation plays the role of a "concept revealer" in a model.

We consider that a mental model is either a path in the contextual graph (in actor activity modeling) or a sequence of independent subtasks that define actors' activities (in group activity modeling). The mental model is developed from the mental representation in the actor version, but initially must be built in real time from independent subtasks and then developed in the group version. The changes in the group version, with respect to the actor version, are the recording of independent subtasks in the mental representation instead of mental models and the cyclic use of the contextual graph to build a mental model. The notion of group activity is dynamically modelled at two levels: first, at an operational level (turn sequences), and second, at the implementation level (cyclic use of the directed contextual graph). Another important concept is the shared context that makes possible the cyclic use of a directed, acyclic and series-parallel contextual graph and the existence of CxG-based simulation as a natural function of the CxG software. The shared context is used as an inference engine for group-activity building, the engine assuring the turn mechanism in CxG-based simulation. A turn is a local contribution of an actor to the group activity, and the turn mechanism plays a synchronizer role in the dynamic assembling of independent subtasks for building mental models, thanks to reserved contextual elements that monitor turn management. The CxG-based simulation is a function of the CxG formalism for group activity. This tool also offers the possibility of managing other tasks simultaneously (jointly with their realization), such as negotiation, changes in objectives, and looking ahead, thanks to context management. It is possible to "replay" the simulation in different contexts.

Contextual reasoning explains the mental-model development as a path from the input to the exit of the contextual graph, on which contextual elements are instantiated. Contextual reasoning can be nonlinear (e.g. glocal search, voting system, or the Contextualisation-Decontextualization-Recontextualization approach) (Brézillon 2023), and contextual elements themselves, with their implementation as pairs of contextual and recombination nodes, behave as units of contextual reasoning at an operational level. The CxG formalism is effective for modeling an activity, not for visualising its evolution. A tree representation supports a simple visualisation of contextual reasoning (and all its known variants) in the CxG formalism. The mental-model tree view shows to actors the relevant contextual elements as a proceduralized context (the ordered sequence of instantiated contextual elements) and postpones actions to quickly make decisions.

By putting context front stage in the Contextual-Graphs formalism, we obtain a uniform representation of knowledge, information, reasoning and context coming from sources of different natures. We thus have been able to model activities in very different domains (subway, army, different types of cancer in medicine and workflows), thanks to the Contextual-Graphs formalism that is very simple to use. Finally, the CxG formalism is a passport for intelligent systems based on human experience. The "hard kernel" of our approach is the explicit modelling of context in activity, which leads to a homogeneous view of how a class of AI systems can become context-based intelligent systems, especially context-based intelligent assistant systems (CIASs) (Brézillon 2023) which aim at reuse and extend human experience based on how this experience grows. CIASs developed in the CxG formalism offer the possibility to model contextual reasoning with context-based simulation, a powerful modeling tool for CIASs.

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