Chapter 22
The Role of Context and its Elements in Situation Assessment

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Abstract This chapter presents an analysis of the concept of context in situation assessment. Situation assessment is the process that develops a situation awareness, which is the basis for deciding which action to perform in a given situation. The contributions of the research documented here include a knowledge level model of situation assessment, a context element ontology and an analysis of the role of context in situation assessment, which are based on models of situation awareness and context found in the literature. The knowledge level model includes a task decomposition, a task description, and a goal analysis. Finally, this view is illustrated in a short example.

22.1 Introduction

Situation awareness represents the degree to which someone understand a given situation. Although situation awareness has been termed *"ill-defined"* by Sarter and Woods (1991), lately, Endsley's view on situation awareness (Endsley 1995) has more or less been adopted by the research community (Breton and Rousseau 2003). Another concept that is ill defined is *context*. One of the reasons that a definition of context is hard to nail down is that *what context is changes with its context*. Thus, the concept of context is more easily analyzed in relation to something else.

The goal of the research presented here is to understand and describe the role of context in situation assessment, while the contributions are three-fold: (1) A knowledge level model of situation assessment in the form of a task decomposition, task description, and goal analysis. (2) An ontology of the context elements of situation assessment that is used to analyse the role of context in situation assessment. (3) A simple example that illustrate this view. This research is based on the work documented in Gundersen (2013).

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P. Brézillon, A. J. Gonzalez (eds.), *Context in Computing,*
DOI 10.1007/978-1-4939-1887-4_22

The rest of this paper is structured as follows: In Sect. 22.2, we present related reseach in situation awareness, while related research in context is presented in Sect. 22.3. Some aspects of the concept situation is discussed in Sect. 22.4. Then, we model situation assessment in Sect. 22.5, and analyse the elements and roles of context in situation assessment in Sect. 22.6. An example is presented in Sect. 22.7, and finally, in Sect. 22.8, we conclude and provide some future work.

22.2 Situation Awareness

Several models of situation awareness exist, and Rousseau et al. (2004) distinguish between descriptive and prescriptive models. Descriptive models describe the cognitive processes related to situation awareness, while prescriptive models are used to simulate situation awareness. Salmon et al. (2008) did a systematic review of situation awareness models, and their focus was on the three most cited ones. Apart from Endsley's model, these are models proposed by Smith and Hancock (1995) and Bedny and Meister (1999). All three models are descriptive. Smith and Hancock take an ecological approach to defining situation awareness while Bedny and Meister use activity theory to describe situation awareness.

According to Smith and Hancock, situation awareness *is adaptive, externally guided consciousness*. They insist that the agent's behavior, which is guided by the situation awareness, is shaped by the agent's interaction with the environment. Thus, situation awareness can only be analysed in context of the agent's environment, but only given *a specified task and concrete performance criteria*. These observations provide insight into situation awareness. However, as their situation awareness framework can only be analysed in the context of the agent's environment, it does not provide good support in analysing situation awareness in general nor in specific domains.

Endsley's three level information processing model (Endsley 1995) has received most attention. She defines situation awareness as *"the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future"*, (Endsley 1995 p. 36). The process of achieving this state of knowledge, situation assessment, is comprised of three sub-processes, called levels, which are illustrated in Fig. 22.1. Level 1 concerns perception of situation elements, while level 2 concerns comprehension of the current situation. Finally, when the situation elements are perceived and the situation is comprehended, one can project the future state of the elements constituting the situation. The main strength of the model is its intuitive description of situation awareness, as also is noted by Salmon et al. (2008), and the three layers that specify the main processes of situation assessment. Our model is based on Endsley's, and the situation assessment task tree has Endsley's three levels as child nodes, which are decomposed further.

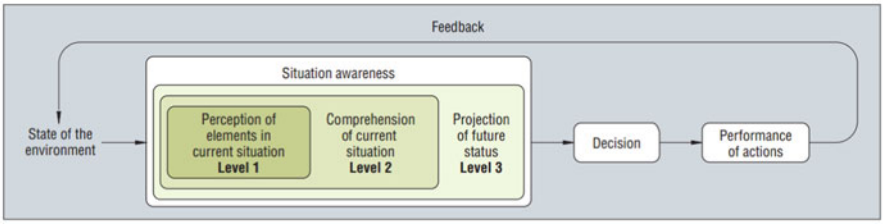

Fig. 22.1 The three levels of situation awareness according to Endsley. (Source: Endsley and Hoffman 2002)

22.3 Context

There is a distinction between the context of a situation element and the situation. The context of a situation element can be other situation elements, as pointed out by Manilla and Moen (1999), but the context of the situation itself is another matter. For example, a situation might exist as part of a simulation, a training exercise or a real-world scenario. Which one of these that applies is a highly important bit of information. This distinction is not made by Day and Abowd. They define context as *any information that can be used to characterize the situation of an entity [. . .]* (Abowd and Dey 1999). Given that a situation is made up of situation elements and relations between them, Day and Abowd's definition include all relations and situation elements except for the target entity as context information. This means that properties of the target entity is not context, such as the color of the shoes a patient is wearing in a diagnostic task where a patient is the target. The definition is too broad to help in structuring information.

Kofod-Petersen and Mikalsen (2005) extends the above definition of context to *"the set of suitable environmental states and settings concerning a user, which are relevant for a situation sensitive application in the process of adapting the services and information offered to the user"*. However, while being more specific, this definition restrict context to environmental states and settings, which again makes the color of the shoes not context information.

There is a distinction between the *role* and the *elements* of context in problem solving according to Öztürk and Aamodt (Öztürk and Aamodt 1997; Öztürk 1999). The context elements can belong to the generic context ontology or the domain knowledge. The generic context ontology distinguishes between the problem solver and the external situation, and it is defined from the point of view and emphasizes the active role of the problem solver. Hence, context can be divided into internal and external context, where internal relates to the problem solver and external relates to the external situation. They argue that the roles of context when solving a problem are to choose the most relevant solution and focus the problem solving process. The work enforces structure on context as it distinguishes between the roles and elements of context. Furthermore, it structures the elements in an ontology, which supports context analysis. Our research is based on Öztürk and Aamodt's view on context.

22.4 Situations

In Gundersen (2013), we argued that a situation is not only comprised of situation elements, but also the relations describing how the situation elements relate to each other. Endsley's theory of situation awareness does not explicitely consider relations being relevant parts of situations. Kokar et al. (2009) argues that relations are important parts of situations, and can only be analysed through comprehension and thus at the second level of Endsley's situation awareness theory. The only situation elements that are considered are physical and palpable elements existing in the real-world that can be perceived. Hence, immaterial situation elements such as goals, dreams and hopes that can be extremely important in order to understand a situation are not considered at all. This excludes what Kolodner called intentional situations (Kolodner 1993). Our analysis of situations include immaterial situation elements, and we discussed events and different definitions of these in detail. We consider events as situation elements in themselves, although they can be interpreted in many ways. For example Baclawski et al. (2002), treats events as a type of relations, but we have found it fruitful to consider events as situation elements. See our work on case-based reasoning for decision support for further details on the advantages this position provides (Gundersen et al. 2013; Gundersen and Sørmo 2013).

Our previous treatment of situations did not discuss in detail the aspect of time and space. Situation is defined quite loosely in Wikipedia (2014) as *"a concept relating to a position (location) or a set of circumstances."* A more meaningful definition is provided by Merriam Webster's Dictionary (2014), which states that a situation is *"all of the facts, conditions, and events that affect someone or something at a particular time and in a particular place."* In this context, "in a particular place" does not mean a point in a volume of space. It can mean a room, a building, the city of London, the planet Earth or this part of the known universe, so it is not necessarily a point in space, but a part of a volume of space. "A particular time" can clearly be interpreted as a point in time, but when talking about a situation one can mean a period of time, such as the Early Middle Ages. So, the expression does not have to mean a point in time in the same way as a particular place does not mean a point in a volume of space.

As part of the definition of the first level of situation awareness, Endsley touches on upon the definition of situation that is used implicitly in her work. The first level of situation awareness is "the perception of the elements in the environment within a volume of time and space," so the elements relevant for the situation is confined in a volume of time and space. Another definition of situation is the one proposed by McCarthy and Hayes (1969), which is that a situation is *"the complete state of the universe at an instant of time"*. This definition is not just only highly impractical to reason with, as open systems are not fixed and possibly not completely available, which is noted by Baclawski et al. (2002), but it defies the commonly acknowledged definition which confines a situation to a part of the universe. Situation semantics attempts to narrow down the definition of a situation to "parts of the world, clearly recognized (although not precisely individuated) in common sense

and human language." This is a quotation from Devlin (2006), which again quotes Barwise (Barwise and Perry 1980).

Consider a situation in which something explodes. This situation does not change at every time step, although the explosion expands continuously; it is more like the situation stretches out. A situation description enforces a certain level of detail, and this level of detail typically is held constant during the description of a situation. The situation is also relevant only to parts of the world around the explosion. The part of the world that the explosion is relevant for can be smaller or bigger based on the energy released by the explosion.

Our definition of a situation is focused on the elements forming the situation, *the situation elements*, and the relations between them. Hence, a situation can be described by the situation elements and relations forming the situation at any given point in time. A situation can stay the same over a period of time, and its volume is defined indirectly by the situation elements. Hence, one can say that a situation is defined by the situation elements and the relations between them contained within a volume of time and space. The context of a situation is intrinsic to observers and their situation assessment and will differ for each. The context include properties of the observer of the situation, the observer's environment, some elements and properties of the situation as well as the environment of the situation.

22.5 Situation Assessment

In order to get a better understanding of the role of context in situation assessment, the process of situation assessment itself has to be understood better. Hence, we have done a knowledge level analysis of situation assessment. First, the results of this knowledge level analysis, which are a task tree decomposition, a goal analysis and a detailed task description, are presented. Then, further detail is provided through a formal description of situation assessment.

22.5.1 Situation Assessment at the Knowledge Level

In order to enable a detailed discussion of what situation assessment constitutes, a model of situation assessment has been developed at the knowledge level (Newell 1982). Parts of this model is presented here and includes goals, a task model and task descriptions. Uschold (1998) notes that the purposes of knowledge models fall into two categories. The purpose of this model is first and foremost to (1) *enhance human understanding and communication* for enabling a discussion, which hopefully will lead to (2) *system engineering benefits* during development of decision support systems.

The knowledge model combines Endsley's three level information processing model with the above definition of situation, and it is described from the view of

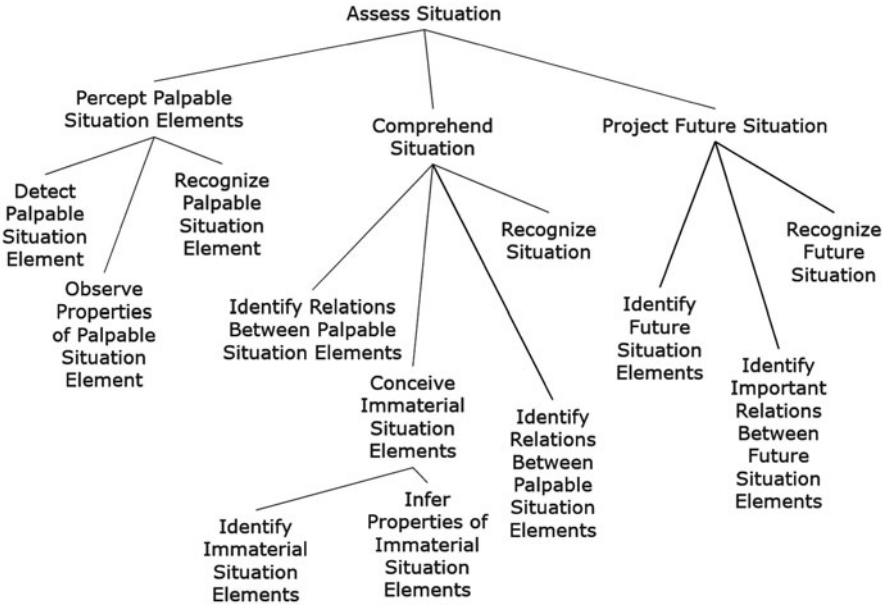

Fig. 22.2 A task tree decomposing the task hierarchy of the situation assessment process

an observer. Thus, as illustrated in Fig. 22.2, situation assessment is decomposed into tasks mirroring the three levels of situation awareness. Their subtasks again specify which components of a situation can be realized in each of the three levels. A detailed description of all the subtasks is beyond the scope of this paper, and we restrict our description to *Assess situation*, *Perceive Palpable Situation Elements*, *Comprehend Situation* and *Project Future Situations*. A summary of this description is provided in Table 22.1. The analysis does not consider memory, so the result is a stateless information processing model. Memory does clearly play a role in situation assessment. Although a complete analysis should consider memory, not considering it simplifies the situation assessment analysis while providing new insights. Hence, it is a sensible first step.

Our interpretation of the task *situation assessment* is that it is to *become aware of the situation and its probable future outcomes*, which we interpret as its goal. The task requires input external to the observer, which is not restricted to being human, so the input data can come from sensors or senses. A subset of the external data is the situation context, but we think of it as an essential part of situation assessment so we emphasize it, and thus the input is external data and the situation-related context. The situation is dynamic while the context is static for the situation. The situation can be described in many different contexts, so the context will influence a decision even though two situations are completely similar. For example, given a specific situation, a more risky decision can be made if the context is a training simulation compared to if it is a real-world scenario. In a training context, an action can be made that will

Table 22.1 A summary of the tasks *Assess situation*, *Perceive Palpable Situation Elements*, *Comprehend Situation* and *Project Future Situations* from Fig. 22.2

Level 0: Assess situation	
Goal	Become aware of the current situation and its probable future outcomes
Input	External data, situation-related context
Output	Subjective situation description, subjective future situation descriptions containing the operations leading to the future situations, subjective situation context
Description	Signals external to the observer that include the situation context are interpreted by the observer to develop an internal description of the current situation, the evolution into possible futures and the situation context
Level 1: Perceive palpable situation elements	
Goal	Identify all relevant palpable situation elements and their properties
Input	External data, situation-related context
Output	Subjective descriptions of palpable situation elements, subjective situation context
Description	Detect and describe palpable situation elements and their properties from the external data
Level 2: Comprehend situation	
Goal	Map out relations between situation elements and identify immaterial situation elements that influence the situation
Input	External data, subjective decriptions of palpable situation elements, subjective situation context
Output	Subjective situation description
Description	Make a complete situation description by analysing the palpable situation elements and the external data and identify immaterial situation elements and infer the relationships between all the situation elements
Level 3: Project future situations	
Goal	Identify the most probable and relevant futures that can be evolved from the current situation
Input	Subjective situation description, subjective situation context
Output	Subjective future situation descriptions containing the operations leading to the future situations
Description	Infer the possible future situations evolving from the current situation that are relevant for understanding of the current situation

increase the learning experience without considering the consequence. Furthermore, a situation will be assessed differently by two different observers, as they have different context, such as different experiences and goals.

As is shown in Endsley's three level information model, see Fig. 22.1, the output of situation assessment is the input for the decision process. Thus, the product of situation assessment is used for making a decision about what to do in a situation,

so it is not a decision nor an action, but information that can be used to make a decision about an action. An important property of this output is that it has to be detailed enough to inform the decision making. This rules out an output of the situation assessment to be of the type *"bad situation"* or *"good situation,"* as this will not provide enough information to decide which action to select in order to get out off or maintain status quo. So, situation assessment requires an observer to build an internal representation of the current external situation. Furthermore, it requires the observer to project the future state of the current situation. The current situation can lead, not only to one, but many possible future situations or futures. The futures can be described by situation elements and relations that have evolved from the current situation. A future state, described by a set of situation elements and relations, together with the operations that evolved the current situation to that specific future is a future description. Also, the observer is required to recognize the context of the situation. Given all this information, a decision about which action to perform can be made.

The subtasks of *situation assessment* are the three levels of Endelsy's situation awareness model. The first level of situation awareness is about perception, which is internalizing the external world through signals interpreted by the senses. Hence, the goal of the task *perceive palpable situation elements* is to identify all relevant palpable situation elements as well as their properties from the external data. The output of this task is a description of the identified situation elements. However, not all situation elements can be perceived. Only elements that have observable representations in the physical world can be, which exclude dreams and intentions that have not been communicated. Thus, events, physical objects and communicated information can be perceived in the first level. Immaterial objects, such as dreams and intentions can only be identified through comprehending the situation and the relationships between palpable situation elements. Therefore, the goal of the task *comprehend situation* is to map out relations between situation elements and identify immaterial situation elements that influence the situation. This is done through analysing the external data as well as the palpable situation elements that have been identified. The output of comprehend situation is the observer's description of the current situation, which is the set of situation elements and relations that the observer believes to constitute the current situation, which of course can be wrong. The third level of situation awareness is projecting the future state of the situation, and thus the goal of the task *project future situations* is to identify the most probable and relevant futures that can be evolved from the current situation. By forwarding the current situation or making what-if scenarios, the future can be projected, which can result in a set of futures and the operations leading to these futures. The futures and the operations leading to them are the output of this task. All the subtasks of situation assessment will benefit from knowing the situation-related context, as this information will inform the search for situation elements, relations and immaterial situation elements.

22.5.2 Situation Assessment: A Formal Treatment

A situation, S_i, at a given point in time, i, is the set of situation elements, E_i, and the relations between them, R_i, that exist at that time (note that the volume of the situation is defined by the situation elements):

$$S_i = \{E_i, R_i\} \tag{22.1}$$

Situation elements can be both palpable, p, and immaterial, a. Palpable situation elements are elements that exist in the real-world and can be observed directly by an observer, such as physical situation elements and events. Hence, the set of all situation elements, E, is defined as follows:

$$E = \{p, a\} \tag{22.2}$$

The perceived and comprehended situation, S_i^o, which is the observer's, o, overview of the actual situation, S_i, is comprised of a set of situation elements, E_i^o, and relations, R_i^o, that might and might not overlap with the actual situation:

$$S_i^o = \{E_i^o, R_i^o\}, \tag{22.3}$$

$$E_i^o = \{I_i + N_{E,i}\}, \tag{22.4}$$

$$R_i^o = \{J_i + N_{R,i}\}, \tag{22.5}$$

where $I_i \subset E_i$ and $J_i \subset R_i$. Thus, I_i and J_i are correct observations of situation elements and relations, respectively, while $N_{E,i}$ and $N_{R,i}$ are errors.

D_i is the external data the observer receives, i.e. visual images, sounds or data in the computational sense. The tasks *perceive palpable situation elements*, *comprehend situation* and *project future situation* can be represented as functions, $Perceive$, $Comprehend$ and $Project$, respectively:

$$Perceive : D_i, C_i \rightarrow p_i^o, C_i^o \tag{22.6}$$

$$Comprehend : D_i, p_i^o, C_i^o \rightarrow S_i^o, \tag{22.7}$$

$$Project : S_i^o, C_i^o \rightarrow F_i^o, \tag{22.8}$$

where p_i^o is the set of palpable situation elements perceived by the observer, C_i^o is the observer's understanding of the actual situation context, C_i, and F_i^o is a set of descriptions of possible futures deemed relevant by the observer.

$$F_i^o = \{F_{1,i+\Delta t_1}^o, F_{2,i+\Delta t_2}^o, \ldots, F_{n,i+\Delta t_n}^o\}, \tag{22.9}$$

where the range of Δt is $[1, \infty]$.

The set of descriptions of possible futures, as projected by the observer, might and might not overlap with the actual set of descriptions of possible futures, F_i, at a given point in time, i:

$$F_i = \{F_{1,i+\Delta t_1}, F_{2,i+\Delta t_2}, \ldots, F_{n,i+\Delta t_m}\} \tag{22.10}$$

A future description, such as for example $F_{1,i+\Delta t_1}$, is a future situation, comprised of situation elements and relations that are evolved from the current situation S_i, and the set of operations, $O_{1,i+\Delta t_1}$ that evolved the current situation to the future situation, such that $F_{1,i+\Delta t_1} = \{E_{1,i+\Delta t_1}, R_{1,i+\Delta t_1}, O_{1,i+\Delta t_1}\}$.

Then, the task *assess situation* can be represented as a function as follows:

$$Assess : D_i, C_i \rightarrow S_i^o, F_i^o, C_i^o \tag{22.11}$$

The situation awareness, A_i^o, at a given time, t, that an observer, o, has obtained of the situation, S_i, can be defined as follows:

$$A_i^o = \{S_i^o, F_i^o, C_i^o\}, \tag{22.12}$$

The degree of awareness that an observer has of a situation, S_i is a metric for measuring the similarity between A_i^o and $A_i = \{S_i, F_i, C_i\}$, the actual situation, future and context:

$$AwarenessDegree : similiarity(A_i, A_i^o) \tag{22.13}$$

Hence, the observer's degree of situation awareness is said to be complete if the following three conditions hold:

1. $S_i^o \cap S_i = S_i^o = S_i$,
2. $F_i^o \cap F_i = F_i^o = F_i$,
3. $C^o \cap C = C^o = C$,

and non-existent if:

$$S_i^o \cap S_i = F_i^o \cap F_i = C^o \cap C = \emptyset \tag{22.14}$$

In all other cases, the degree of situation awareness is said to be incomplete.

22.6 Context in Situation Assessment

A knowledge level model of context for situation assessment will bring clarity to how context influences situation assessment. Here, we present a knowledge level context ontology for situation assessment (*situation assessment context ontology*), which is founded on the knowledge level context ontology (Öztürk and Aamodt 1997; Öztürk 1999) (*context ontology*). Our ontology clearly specifies the elements of context that are related to situation assessment, which are based on the definitions of situations and situation assessment presented above. The presented ontology is used as a basis for a discussion on the role of context in situation assessment. Finally, both the elements and the role of context in situation assessment are illustrated in a short example.

22.6.1 A Situation Assessment Context Ontology

The context ontology is defined from the point of view of the problem solver. Thus, internal context is internal to the problem solver and the external context is external to the problem solver. The external context is related to the target of the problem solving process and the environment, where the environment is the environment of both the target and the problem solver. This ontology applies for context in general. However, by following the same train of thoughts, a similar ontology specialized for situation assessment can be developed.

Our attempt at capturing an ontology for situation assessment is defined from the view of the observer, and the target is the situation. The situation assessment context ontology is detailed further than the context ontology by specifying which elements of a situation assessment process can be regarded as context elements. It can be more detailed, as it is specific for context elements of situation assesment and not for context in general. Similar to the context ontology, all context elements can further be classified as *interactive* or *independent*. However, the ontology does not capture this aspect. The situation assessment context ontology emphasize the four main components of a situation assessment process, which are the observer, the environment of the observer, the situation and its environment, and the ontology indicates the specific elements of these components that can provide context. It is an ontology of context elements. However, the term "context element" is not used in the ontology, except at the top level, because of readability of the figure. So, except for the leaf nodes in the ontology, all nodes should be read as if the term "context element" is appended.

As can be seen in Fig. 22.3, the top component is *situation assessment context elements*, which is divided into context related to the observer and to the observed situation, *observer-related* and *situation-related* respectively. The observer has internal and external context, where the *internal observer* is related to the internal state of the observer, and the *external observer* is related to the physical properties of the observer and the environment of the observer. Furthermore, the external observer context is comprised of the *observer* and the *observer environment*. The *situation-related* distinguishes between the *situation* and the *situation environment*. Situation can be *situation elements*, *relations between situation elements* and *properties* of these. Finally, the *situation environment* contains *elements*, relations between them, *relations between elements* and the properties describing them, *properties of situation elements and relations*.

The environment of the observer is not necessarily the same as the environment of the situation, which is emphasized by the ontology. Consider the situation in which a car driver observe a situation outside the car. Then the car driver's environment is the inside of the car, maybe with loud music, while the observed situation's environment is the street with the surrounding buildings where no music can be heard. If the car driver leaves the car to walk in the street, then the two environments suddenly overlap.

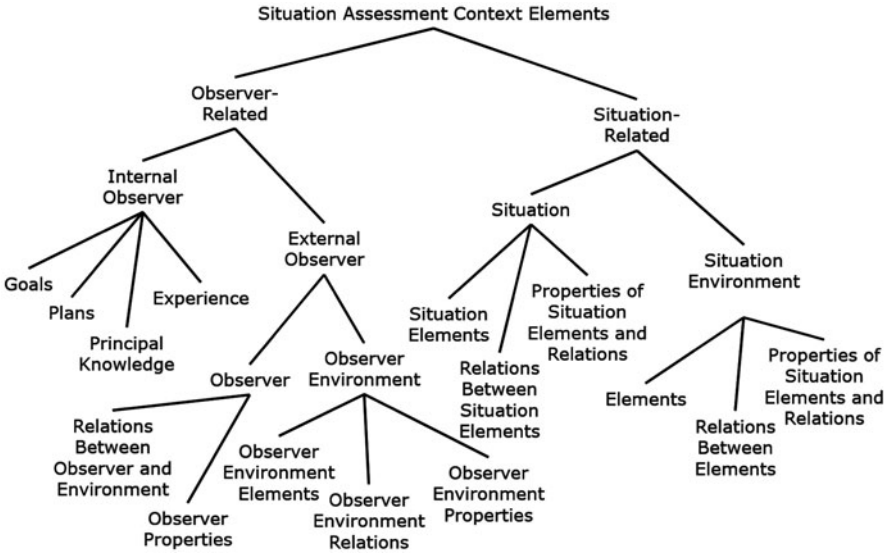

Fig. 22.3 An ontology that categorize the context elements of situation assessment

22.6.2 The Role of Context in Situation Assessment

Öztürk distinguishes between the context elements and the role of context (Öztürk and Aamodt 1997; Öztürk 1999). The analysis of context is performed in relation to problem solving, and two roles are identified: (1) Focus and (2) relevance. Context focuses the problem solving process so that it becomes more efficient and ensures the relevance of the solution. In situation assessment, context plays similar roles for the observer.

As problem solving, situation assessment is a process, which can be both slow and fast. A proper understanding of the situation context will increase the efficiency of the situation assessment. Typically, an expert with long experience will assess a situation faster than a novice. However, the efficiency of an expert can be reduced, if the goal of the expert is not specific to the assessment, but related to something else. Thus, the internal observer-related context elements affect the efficiency of the situation assessment. Also external observer related context elements can reduce the efficiency, which loud music in the car is an example of. Correspondingly, situation-related context elements can affect the efficiency. An act of violence against someone is generally a violation of the law. However, the penalty of the same act will increase if the target of the violence is a police officer. Thus, a property of a situation context element can influence the situation assessment. For a drilling engineer that monitors the drilling process remotely by reading graphs of real-time measurements, the situation can be assessed more efficiently if the geology is known. The geology can be considered a property of an element of the situation environment.

The outcome of the situation assessment process was specified in Sect. 22.5.2 as the situation awareness, which included the situation context. A false conception of the situation context can lead to a situation description that includes too many or too few situation elements and relations, which will make both the situation description and the possible futures less accurate or maybe even completely wrong. Finding a pet when assessing the container contents becomes easier when you know that you are looking for a stick animal. Here, stick animal is a property (the class) of the situation element pet, and the situation description depends on the perception of the situation element. Likewise, a false conception of the situation context can also lead to less relevant projected futures. For example, the context information that person A is the national champion in Karate might change the future projections made by person B considering person A.

22.7 Driving Past the School of Mischief

The following situation has to be assessed by a car driver, the observer, o, driving a car on a street: A child stands on the sidewalk in front of a building, and a paper bag is lying in the middle of the road. The driver, o, has to make a decision about whether to drive over the paper bag or not. Note: Time is omitted in this example. The situation elements, E, include the child and the paper bag, while the building is part of the situation environment:

$$E^o = \{child, building, paperbag\} \tag{22.15}$$

The driver infers that the paper bag might belong to the child, which is a relation between the situation elements:

$$R^o = \{child\_stands\_on\_the\_sidewalk, child\_owns\_the\_paper\_bag\} \tag{22.16}$$

So, the driver's situation description, S^o, is as follows: $S^o = \{E^o, R^o\}$. Based on this situation description, the driver projects two futures. One in which the child runs into the street to pick up the paper bag, F_1 and another where the child stands still on the sidewalk, F_2. Thus, $F^o = \{F_1, F_2\}$. The context is empty except for the building, $C^o = \{building\}$. Hence, the situation awareness is:

$$A^o = \{S^o, F^o, C^o\} \tag{22.17}$$

In this situation, the driver might choose to slow down to see whether the child runs into the street, but drive over the paper bag if not.

In a slightly different situation where the driver has some context information the decision might be another one. If the driver knows the building as the *School of Mischief* and recognizes the child as bob, the school's star pupil, the situation context can influence the assessment. Now, the context contains one property describing the building and another property describing a situation element:

$$C^{o,1} = \{building : \{school\_of\_mischief\}, child : \{bob, infamous\_pupil\}\} \tag{22.18}$$

The following relations might be inferred:

$$R^{o,1} = \{bob\_owns\_the\_paper\_bag, paperbag\_contains\_a\_large\_stone\}, \quad (22.19)$$

and thus, $S^o = \{E^o, R^{o,1}\}$. The set of futures might now include bob standing still on the sidewalk to watch the driver ruin his car when he drives over the big stone concealed in the paper bag, F_3. So, $F^{o,1} = \{F_1, F_2, F_3\}$. The alternative situation awareness then is:

$$A^{o,1} = \{S^o, F^{o,1}, C^{o,1}\}, \quad (22.20)$$

which might make the driver to decide not to overrun the paper bag.

22.8 Conclusion and Future Work

In this paper, a knowledge level model of situation assessment in the form of a task decomposition, task description, and goal analysis is presented and given a more formal treatment. An ontology of the context elements of situation assessment is presented and is used to analyse the role of context in situation assessment. Finally, a simple example that illustrates how context influences the situation assessment is presented.

In our future work, we will detail the knowledge level model further with detailed descriptions of all subtasks in the task decomposition tree and provide the formal description of these tasks. The model will be the foundation of a conceptual reference architecture for decision support systems that assess situations in real-time based on streaming data.

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