Case-Based Situation Awareness

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***Abstract*—Situation-aware case-based decision support (SACBDS) systems comprise two distinct parts: situation awareness (SA) and case-based reasoning (CBR). The SA part keeps a finite history of the time space information of the domain and uses rules to interpret cues from the environment with respect to an individual user's context, and then anticipates future situations by performing statistical inference over historical data. The CBR part is the part that seeks to accomplish a particular task with knowledge of the environment from the SA component. This paper discusses the fusion of the CBR model and the SA model into a case-based situation awareness (CBSA) model for situation awareness based on experience rather than rule, similarity assessment and problem solving prediction. The CBSA system perceives the users' context and the environment and uses them to understand the current situation by retrieving similar past situations. Every past situation has a history. The future of a new situation (case) is predicted through knowledge of the history of a similar past situation. The paper evaluates the concept in the flow assurance control domain to predict the formation of hydrate in sub-sea oil and gas pipelines. The results provided the CBSA system with greater number of accurate predictions than the SACBDS system.**

Keywords: **Situation awareness; Context awareness; Case-based reasoning; Human cognition; Hydrate formation.**

I. Introduction

Situation awareness (SA) is a cognitive process in decision making and is defined as "the perception of 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" [4]. Endsley's situation awareness model [4] is a widely accepted abstract framework of situation awareness. Endsley specifies three main levels for realising situation awareness which include perception, comprehension and projection. In the perception level, key cues from the environment are picked up by an operator's sensory and attention system. These cues will then be used by the operator to understand the current situation in the comprehension stage. A person also has the capability to predict how situations may evolve i.e. projection into the future. Endsley has also advocated a goal-oriented design for a focused situation awareness [5]. In Jones et al [10] goal influences what the operator perceives, comprehends and anticipates in a computational model of goal-oriented SA for the military command and control.

A related concept to goal is the notion of context. Dey [3] defines context as "any information that can be used to characterize the situation of an entity". A system is said to be context aware if it uses context to provide relevant information and services to the user [14]. Context awareness was introduced by Schilit [17] to develop an application that adapts to the location of use, nearby people and objects, and the change of those objects over time. With technology advancement and the rapid growth of mobile computing in recent times, context awareness has attracted greater research attention [6]. Context, like goal, acts as a filter to SA. Context filters SA in relation to the specific need of individual operators. Feng et al [6] incorporated user context in a computational model of SA for exploiting goal-based contextual information to achieve user-specific situation awareness using agents. The agents, one for each individual operator, communicate with the situation model and extract information of relevance for presentation to their respective users in accordance to the user context. Defining necessary heuristics based on bounded definition of the domain (command and control) and responding to each and every new development was difficult due to Feng's rule-based decision support engine [6]. Rule based systems require a careful procedure in order to ensure the consistency of the rule-base. A set of rules is worked out in order to understand the situation. Background knowledge is given implicitly in the rules and the order of the rules. Rule-based systems are not able to work with experiences [7] and rules are created by a limited number of experts. Their knowledge and ignorance are implicitly reflected in the rules [10]. Unlike the experience-based systems, the only way to explain a decision in rule-based systems is to report the chain of inferences. Experience-based systems such as case-based systems contain more explicit knowledge which can be used to enrich the explanation of a decision and thus making it more intuitive. Case-based systems have several advantages compared to classical rule-based systems. It facilitates better maintainability and expandability than rule based systems [16] since new knowledge is added by integrating new cases automatically to the case-base. Partial matching is another advantage of case-based systems. Even if a case does not match exactly, it can still be considered for problem solving [15].

Kofod-Petersen et al [12] used case-based reasoning in modelling SA in an ambient intelligent system. The ”perception” and the ”awareness” layers of the system are comparable to Endsley’s perception and comprehension layers of situation awareness. The third (sensitivity) layer adapts the ambient system’s behaviour to the current situation. The sensitivity layer does not anticipate future situations to make it a projection layer. The adaptation of the system to the current situation was possible by combining a user’s context with environmental elements at the perception level.

Vacek et al [20] used case-based reasoning in a computational model of situation awareness for autonomous driving. CBR was used to interpret the current situation and selecting the appropriate behaviour. Future situation behaviours were known by their projected consequences using the expectation value. The expectation value is calculated for each applicable behaviour and the behaviour with the highest overall value is selected as the behaviour of the future situation. Ting et al [19] also applied features of expectations during the projection stage in work on using CBR to build a computational SA model for military operation in urban terrain (MOUT) simulations. The approach uses violation of expectations to determine behaviours or actions. Violation of expectation in the approach is categorised as invariant and variant. Invariant expectations must be fulfilled or else there is danger while the violation of variant expectations is merely an alert of possible threats. The system of both Vacek [20] and Ting [19] rely only on cues from the environment without considering the user’s context.

In this work, a case-based reasoning approach to computational model of SA, experienced situations are stored as cases and experiences are recalled by comparison with a current experience [8]. To recall past experiences, the system uses environmental elements and user context that are fused and converted into a more abstract symbolic representation at the perception layer. Context enables the system to customise SA to the specific need of an individual operator since the same SA may have different meanings and usages to different operators in the same environment. The nature of how the current situation may evolve is predicted through the progressions or history of similar past situations. No previous work on case-based situation awareness uses context and the environment in all the layers of situation awareness.

The remainder of the paper is as follows. The next section discusses the human cognitive processes followed by the methodology for the approach. We then present the system architecture and show how it can be applied in a problem domain (hydrate formation). The system architecture is evaluated from that application. Finally, the paper is summarized and concluded with a critical discussion.

II. Cognitive processes in case-based situation awareness

Situation awareness (SA) is a function of the operators’ minds, their mental models of evolving task situations in complex, dynamic and high-risk environments. It is a state of awareness and understanding of the domain and other situation-specific factors affecting current and future goals, for the purpose of rapid and appropriate decision-making and effective performance. Representations of domain knowledge for situation awareness are stored in long-term memory (mental model or schema) [4]. The level of SA that an operator has is dependent on the complexity of the available mental model. As an operator becomes more experienced with the domain, their mental model becomes more developed, which explains why experts are better at integrating multiple cues compared to novices [9]. The difference between the expert and the novice in their level of SA is experience-based reasoning. One of such reasoning methods is case-based reasoning (CBR). Case-based reasoning is a psychological theory of human cognition that addresses issues in memory, learning, planning, and problem solving [18]. The psychological assumptions of the case-based reasoning paradigm is that memory is predominantly episodic and so it is richly indexed such that experiences are related to each other in many complex and abstract ways. CBR builds on an understanding on how humans assess situations [16], supporting recognition-primed decision (RPD) framework proposed by Gary Klein [16]. The framework emphasises the role of experiences in human decision making processes during time critical situations. Klein pointed out that humans depend more on past experience rather than deliberate rational analysis of possible alternatives during time-critical decision making. For example, when the general domain knowledge is difficult to extract and instead requires reasoning based on local knowledge or where it is difficult to formulate rules describing the situations[7]. CBR also helps in situations of incomplete domain data [15]. Case-based reasoning (CBR) is one of the most effective paradigms of knowledge-based systems[13]. Reasoning by humans is done by recalling memories guided by experiences of their immediate environment and factors that defines or characterised a particular situation. CBR draws from experiences of past cases in order to solve new problems. Operators interpret and understand new situations in terms of prior experiences [18] and preserves the new experience by retaining it in memory.

In case-based situation awareness (CBSA) in figure 1, an individual's ability to acquire and maintain situation awareness is a function of his cognitive abilities based on his context, which in turn is influenced by his experience. An operator senses cues in his environment and uses them with his context to understand the current situation by recalling similar past experiences.

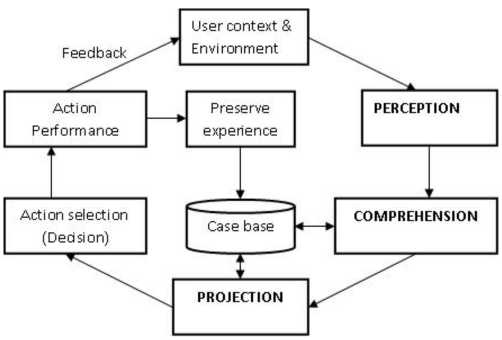

Fig. 1. Proposed Case-based situation awareness cognitive framework

The operator's context include his goal, expectation, location, plan, identity, time and any of his specific needs. An operator also has the capability to predict (projection into the future) how a situation may evolve by recalling and assessing the evolution and solutions of similar past situations. Decision making and action performance are separate stages that proceed from SA but provide a feedback method to direct behaviour in order to attain a desired SA.

III. Methodology

Action research (AR), user-centered design (UCD), and agile development (AD) methodologies were integrated to form a comprehensive research-design cycle (Fig 2). The usefulness of action research methods is that, it links theory and practice, thinking and doing, reflects on the process and the product, achieving practical as well as research objectives[2]. It addresses two challenges, "action" and "research"[1]. In other words, action research addresses social issues in a practical fashion and also makes a contribution to developing and testing theory. This is made possible through cycles of action and reflection with the outcomes of each cycle checked against set plans and goals (Fig 2). The integration of these different methods results in a research-design process comprising three segments; scenarios, agile user-centered design, and business change. The

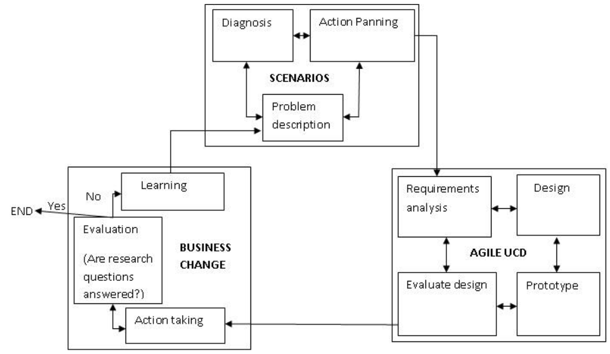

Fig. 2. Action research-design model

starting segment of the research-design process is the domain modeling using scenarios. Even though scenarios are generated at the first segment, they evolved throughout the project lifecycle. Scenarios in our project comprised of problem description, diagnosis, and action planning. The second segment is a user-centered design by agile development method. Agile UCD is an iterative and evolutionary development comprising of requirement analysis, design, prototype, and design evaluation.

Following the design process we worked with practitioners to assess if the design solved organisational problems. This intervention was then evaluated jointly with the practitioners to assess the efficacy of the system architecture on the practical problems they faced.

We evaluate our research-design process on a cyclic basis to see if our specified objectives have been met. After each cycle a new set of scenarios and related systems architecture has been developed from the lessons learnt in the previous iteration. The results of the latest cycle are presented in this paper.

IV. Case-based situation awareness Architecture

In this section, we describe the design of our computational model of situation awareness (CBSA). As shown in figure 3, the CBSA model consists of seven main components: User context, State of the environment, Case-base (situation library), Perception, Comprehension, Projection, and Preserve experience.

Context defines the goal, expectation and the specific needs of the operator. State of the environment collects cues of the current situation and sends the information to the perception component. The perception component delivers data in terms of predefined objects from the context of users and the environment and converts this data into an abstraction in order to feed it into the reasoning process. Comprehension is the retrieval component which extracts all situations of the case-base that have the highest similarity with the current

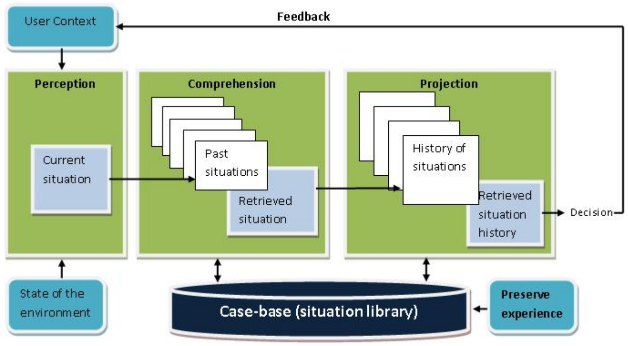

Fig. 3. Proposed Case-Based Situation Awareness Model

situation. The Projection component is where existing knowledge is exploited by a reuse process to identify consequences of the current situation on future situations and present actions that are most suitable to avert the situations. The operator carries out decision making by selecting the appropriate action. The judgment of the operator on the future of a situation is also used to direct further perception of the system through feedback. The last component is the preserve phase which is applied after the selected action is implemented and found to be workable. A newly acquired experience is entered into the case-base in order to update the knowledge base.

A. Case-base (Situation library)

The case-base is the library containing past situations and their solutions (actions that were performed to correct the situations). Building the case-base is dependent on the definition of a case (situation). The main focus lies on an indexing of the situations in order to facilitate and speed-up the search for the most similar situations. The indexing scheme is based on links between different situations and facilitates the search for situations by walking through the case-base. Situations are linked in three different dimensions. In the first dimension, situations are organised hierarchically according to the specialisation of the situation. In the second dimension, situations at the same level of specialisation share a link representing their differences. And lastly, links denote temporal evolutions of situations. The hierarchical arrangement represents an order of situations from the most general to the most specific situation. Specialisation takes place because new instances of concepts or roles are added to the situation. In doing so, the link holds the reasons that led to the specialisation of that situation, i.e. it contains all the differences which make this situation a more specific situation. The edge between two situations holds the difference between these two situations. These links are used for generalisation of new situations. A situation is linked temporally with another, if its contents have changed significantly over time and is a direct evolution of the preceding situation. The applied action that will be appropriate for the temporally succeeding situation is stored together with the link. Due to the applicability of different actions, a situation can have multiple succeeding situations. Each applied action for a given situation is assigned multiple temporally succeeding situations, each succeeding situation together with its probability of occurrence.

B. Perception

The recognition of the status and the dynamics of relevant elements in the environment is the first stage in determining situation awareness.The elements are the entities. Entities are objects in the environment which have attributes. The entity class in this work is the general description of an object in the environment with relevant attributes. The data structure that encapsulates all the relevant information from the operator in the environment is the event. Events are problems defined by the environment and context. An event injection causes the case-based situation awareness model to reassess the relevant entities attributes and their relation with each other which eventually will result in a new situation awareness. This layer recognizes the state of the environment and the user context and then structures the information into a coherent shape.

C. Comprehension (Situation retrieval)

The reason for situation retrieval is to extract the most similar past situation in the case-base relevant to the current situation. The best situations are searched by traversing the case-base recursively along the paths given by the hierarchical organization. Each directly linked specialization of a situation is called a child node of that situation. Starting with the top element, a child node is visited if it matches the current situations. This is done for all child nodes of a visited node. If a node has no matching child nodes, a best situation is found and added to the set of retrieved situations. Single situations from the case-base can be used multiple times because of different mappings of the individual situations. The situation in an experience case holds precondition cues from the environment which act like a pattern or schema for the system to recognise the current situation. These precondition cues mainly consist of some descriptions about the situation. Similarity assessment is conducted by matching the evidence cues of the current situation with the precondition cues. The key cues picked up by the system are used to form an evidence set. When the evidence cues match the precondition cues of an experience case, the situation will be retrieved.

Comprehension through the retrieve process as described above is by situation assessment, which enables one to compare different situations and find out which one is the most similar to the current situation or the other way round, which situations are most dissimilar. Therefore a single value p between 0 and 1 is calculated to express the assessment of the situation, where a higher value expresses a more similar situation. The assessment is based on the evaluation of different features, whereas a feature can only be fulfilled or not.

A function f(x) is defined which assigns a value out of [0; 1] to each feature x. The overall situation assessment is defined by:

$$p = \min\{f(x)|x \in \text{fulfilled features}\}$$

The consequence of taking the minimum is that only the most important fulfilled feature counts and all less important features are ignored regardless of how many apply.

D. Projection (Reuse of situations)

In case-based reasoning, the purpose of the reuse stage is to analyze existing knowledge contained in the retrieved cases and to generate a solution from this knowledge. In this work, case-based situation awareness, the goal is to select the appropriate action for a recognised situation. Different applicable actions are evaluated by the system and the most appropriate action is selected as the best suitable solution. Actions are organised to represent temporal relationships between different situations. When retrieving the appropriate action, the operator has some expectations expressed through context that constrain the assessment. The expectations are monitored while the assessment is being executed. If the expectations are not met, the specific action for the situation may not be executed and the future situation could be in danger. Every situation has a history. Predicting the action and future of a situation is based on the assumption that every situation obtains a history and a future and two situations with a similar history have a similar future [21]. Links are given which represent the temporal evolution (history) of the situation. In order to select the most appropriate action when only one similar situation is extracted, all possible evolutions of the situation are regarded by analyzing the temporal successors of the retrieved situation. In order to detect unfavourable situations at an early stage, the prediction can consider multiple levels of successors. This can be done by combining the assessment along the prediction path using the minimum. The uncertainty of the prediction increases with the length of the prediction path. The assessment of the temporally succeeding situations is done by evaluating the different rates for each situation. Together with the probability of occurrence of each situation, the overall assessment value is given by the expectation value which indicates the applicability of the action. The higher the expectation value is, the better the action is applicable. This expectation value is calculated for each applicable action. The action with the highest overall value is selected.

If multiple situations are extracted, an assessment value for the related action of each situation is assigned. After that, the action that has the minimum value assigned across all the situations is selected.

E. Decision making (Revise)

For good decision making in a given situation, an operator needs to have SA by assessing his current situation. With the SA, he can then consider the options of actions that can be performed and decide on the best options available. This process is facilitated by the operator by using the CBSA system to monitor situations in the domain and recommend possible courses of actions. The human operator then uses his expertise to choose from the options the action he considered most appropriate for the situation. In some circumstances, the actions are modified to suit the current situation. Decision making and action performance are the human operator's tasks carried out with the support of the computational situation awareness.

F. Preserving Experience

The last phase of case-based situation awareness is to preserve newly acquired experience and to provide it for future SA. This phase is executed later when an assessment of the applied action (solution) is known to be workable. In the reuse stage, different situations are extracted representing the situation most appropriate and the best suitable solution are generated based on these situations. In another iteration, the next set of situations with the best similarity is selected according to the situation retrieval phase. Based on this selection, it is now possible to check reflecting on the reuse stage, which temporally succeeding situations are really happening. Given this information, the probability of occurrence can now be updated for all these situations. If for a best situation none of the temporally succeeding situations did happen, a new situation must be created and integrated into the case base through the following steps: (1) Specify all objects of the current situation, that are part of the previous situation and the matching situation and all new appeared objects (2) Make the current situation conform to all these objects and their relations (3) The objects should be generalised to the level of the matching situation.

The newly created situation can then be integrated into the case-base. This implies adding the situation to the case-base and creating all links for this situation. A generalisation of situations in the case-base happens, if the branching factor of a situation is higher than a certain value. In that case, all situations at the same level as the added situation are taken into account. Generalisation is done by identifying the similarities between the new situation and an arbitrary situation at the same level of specialisation. These two situations are replaced by this new generalised situation and added as child nodes.

V. HYDRATE FORMATION PREDICTION WITH CBSA

Natural gas hydrates are solid crystalline compounds that are formed by the chemical combination of natural gas and water under high pressure and low temperature. Wellhead temperatures are normally colder than that of the reservoir, which usually contain water, so that water condenses from the gas at the wellhead and enters the flow lines from the well. If the pressure at the wellhead is high, the gas may remain saturated in the flow lines or become saturated due to further cooling of the gas as it flows through the lines. The above situation results in hydrates formation in oil and gas flow lines causing flow assurance problems. The problem causes flow lines to block making the oil and gas operators to lose millions of dollars. To prevent hydrate formation and maintain steady flow in fields, oil and gas operators carry out flow assurance analysis which includes the prediction of hydrate formation.

1) Hydrate situation awareness modeling: To understand the situation of gas flow in sub-sea pipelines and effectively predict the formation of hydrate requires knowledge of the sea floor (the environment) in addition to knowledge of the pipelines (the domain). The environment of sub-sea gas pipelines is the ocean water. The solar radiation that hits the surface layer of the ocean water is absorbed and mixed by waves and turbulence but decreases as it sinks downward. The temperature decreases very rapidly and continue to fall slowly with increasing dept, making the deep ocean temperature to be between 0-3 degrees Celsius (32-37.5 degrees Fahrenheit) depending on the location and time. This situation increases the density and decreases the temperature of the sea floor until it freezes. Knowledge of the domain, such as the type of material the pipelines are made of, the composition of the gas flowing in the pipelines, the well head temperature, the pressure, flow rate, is also necessary.

2) Perception: The key elements or entities for perception from the environment are solar radiation, and waves. The system senses the incident solar radiation, wind speed, and wind direction. Wave is determined by wind speed and wind direction. The context of users; phase type, composition, pressure, geographical location, distance below sea level, and time are also recognized.

3) Comprehension: Situations in the case-base are the different hydrate forming conditions. Each of the gases has their different hydrate forming conditions. A particular condition comprise of temperature, pressure, phases, composition mol % in aqueous, liquid and hydrate. One of the hydrate forming conditions for methane is identified by the following attributes: temperature (2.5), pressure (3.31), phases (LA-H-V), composition mol % in aqueous (0.12), composition mol % in liquid (0.026), composition mol % in hydrate (0.14.2). The same attributes but different values holds for ethane, propane, isobutane, hydrogen sulfide, and carbon dioxide hydrate forming conditions. The hydrate forming conditions of the gases forms the context of the operators as operators works on different gases. An operator's context together with cues from the environment, such as the solar intensity, wave height, wave speed, and wave length, are used to retrieve past similar situations. A particular situation means different things to different users because of different hydrate forming conditions of the gases. With the same sea floor temperature, flow rate, wellhead temperature, wellhead pressure the system retrieve different past situations based on individual users context.

4) Projection: Projection is the reuse stage of case-based situation awareness. In our case study in hydrate prediction, the system analyses preventive actions contained in the experience library to generate workable actions. In each assessment to retrieve the appropriate action, we varied the expectations of users through varying context.

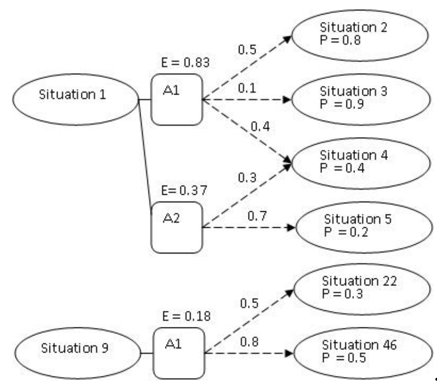

Fig. 4. Selecting the best action by using different actions for temporal linkage of situations

In one context in figure 4, the system extracted only situation 1 and found two possible actions that can be applied in the situation, A1 (methanol) and A2 (silica gel). The overall rating P of each situation, together with the probabilities of occurrence, gives the expectation value of 0.83 for action A1 and a value of 0.37 for action A2. Thus, action A1 (methanol) was selected and presented to the user.

In another context, the system extracted multiple situations. The expectation values for all the actions for all situations are calculated. The led to action A1 (methanol) for situation 1. But because action A1 can be applied in both situation 1 and situation 9, the overall minimum of that action is A1 from situation 9. The action A2 for situation 1 with an assessment value of 0.37 was extracted by the system.

VI. Evaluations and results

The study investigate the number of accurate predictions of the system with past hydrate threatening situations from a North Sea oil and gas field. It also assess the similarity between the system's recommendations and the expert solutions. Two different alternatives were evaluated: CBSA and SACBDS. Ten engineers working on flow assurance participated in the experiment. Two independent variables were system types and system accuracy. System types had two levels, CBSA and SACBDS. System accuracy is a factor to represent how accurately the system provide SA and actions based on a entered query. A query is entered by subjects into the two different systems to compare their predictions. To estimate how accurate these predictions are, we used the 10-fold cross-validation technique to evaluate the methods. The case-base contains fifty (50) past situations. Five test datasets are taken out of the case-base and matched against forty five train cases in each round of the evaluation. The result in table 1 provided a mean accuracy of 0.8 for CBSA, which implies that out of every 10 predictions eight are correct.

TABLE I
Mean Accuracy

Evaluations	1	2	3	4	5
CBSA	0.81	0.80	0.82	0.78	0.80
SACBDS	0.66	0.61	0.65	0.69	0.82

Evaluations	6	7	8	9	10
CBSA	0.87	0.70	0.84	0.88	0.87
SACBDS	0.62	0.64	0.67	0.88	0.79

In the same experiment, our previous architecture, SACBDS and had mean accuracy of 0.6, signifying six correct predictions out of every ten predictions. We observed that the lesser number of accuracy of the SACBDS is because of the structure of the historical data used in the design. Most of the data on past situations have incomplete attributes which were difficult for the rule-based situation model of SACBDS to interpret.

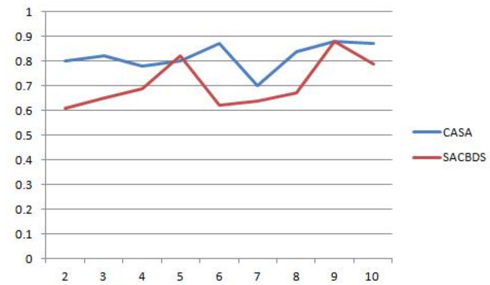

Fig. 5. Accuracy pattern

TABLE II
Similarity Assessment

Test Case	10	6	47	18	34	25
CBSA's Best Case	28	44	12	6	48	No case found
SACBDS's Best Case	21	44	34	19	26	Warning

In the matching results of test cases as shown in table 2, the two methods retrieved the same best match (case 44) using case 6 as a test case. In most of the retrievals, the best match for the unsolved cases are different. For example, in case 10, case 47, case 18, and case 34 as test cases, the CBSA retrieved case 28, case 12, case 6 and case 48 respectively as best matches. For the same test cases, the SACBDS retrieved case 21, case 34, case19 and case 26 respectively as best matches. Using case 25 as a test case, the CBSA found no situation in the case-base that is similar to 25. The SACBDS do not also find any similar situation to case 25 but however, use rules to understand the situation as a Warning situation. The SACBDS recommended actions to be carried out avert the situation.

The ”revise” stage is a manual adaptation level which requires additional human reasoning, increased participation of the engineers in evaluating the recommended actions. The engineers analysed the retrieved cases to decide on the actions that are more relevant.

For instance, evaluating case 21 retrieved by the SACBDS and case 28 retrieved by the CBSA as best matches for the test case 10 revealed that the two cases, 21 and 28 recommended chemical injection as preventive actions. However, two different types of chemicals are recommended by the two methods. Case 21 is supplemental methanol while case 28 supplemental glycol. By expert analysis, injected methanol concentration is normally greater than 98 wt%, while the typical glycol injected into pipelines often falls in the range 67-75 wt% making glycol to have advantage over methanol. Similar advantages were found in case 6 and case 48 over case 19 and case 26 using case 18 and case 34 respectively as test cases.

However, in using case 47 as a test case, the action recommended by the SACBDS had advantage over the one recommended by the CBSA. Engineers evaluated the action of case 12 retrieved by the CBSA and the action of case 34 retrieved by the SACBDS. The action of case 12 is "silica gel" and that of case 34 is "molecular sieves". In analysing these two actions, experts said in recent years molecular sieves have gained popularity over silica gel due to its advantages of providing extremely low dew points and high absorption of water.

The limitation of this SA modelling approach is that it relies solely on past situations in a domain. The effectiveness of the system is dependent on the availability and the number of past situations in its situation library. In some complex and safety-critical environments, operators may not be able to document all their experiences. The system will provide poor SA in an environment where few past situations are preserved, and cannot be implemented where there is none.

VII. Conclusion and Further Work

Experience is a critical element for a human operator to have good situation awareness (SA) [11]. We have used this premise to develop our experience-based SA using case-based reasoning (CBR). The case-based situation awareness system, a computational SA approach, provides a higher number of accurate predictions than the rule-based SA model. However, in problems where no similar situation to the current situation is found in the case-base (experience repository), the rule-based SA model has the advantage of using rules to understand the situation. Also in some domains, past situations are not a good predictor of future action in which case this system is not appropriate.

The work has provided a framework and an architecture for building case-based situation awareness systems. It has shown how the feature of expectations can be incorporated into users context to enable the system meet the specific need of individual operators.

Our further work shall be on using both CBR and rules to have computational situation awareness. To understand the current situation, similar past situations will be extracted from the case-base but for situations of more general relationships, we shall represent related pieces of knowledge in the explicit form of rules.

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