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User focused design and development of a decision support system for electro-optical reconnaissance

C2 Experimentation

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Abstract

The quick and accurate classification of unknown seagoing vessels is essential for the successful fulfillment of naval missions. Operators have limited time to analyze loads of imagery originating from different electro-optical sensors. The decision support system KEOD is being realized to facilitate this task. It is based on two reliable and accurate algorithms for the investigation of object contours as well as the relative locations of visible marks. This paper deals with the graphical user interface and presents the steps from design to deployment. The operator needs to be guided through feeding the algorithms with the needed data and analyzing their results. In order to disencumber human decision makers, the main focus is on providing an interface that is as easy to use and as easy to learn as possible. To reach these objectives, a highly user focused approach has been chosen. Subject matter experts were asked frequently throughout all phases to examine the system and give feedback, based on which it could be optimized and enhanced. Furthermore, experimental tests with experienced officers were conducted under realistic service conditions. The acquired results were used for further optimization, yielding a system that incorporates both scientific knowledge and practitioners' experience.

1. Introduction

The participation in so-called "out of area" missions, e.g., to back a peace keeping mission or to enforce an embargo, is characteristic for nowadays naval vessels' duties. Especially in the context of deployments like Operation Active Endeavor, where the mission is to conduct operations against suspected terrorist activities in the Mediterranean, the quick classification and identification of unknown seagoing vessels is of the greatest importance. Since the start of the operation in October 2001 until February 2006 over 76,500 contacts of interest (COIs) were monitored (AFSOUTH, 2006). Reconnaissance by electro-optical means is of particularly great importance, because it is non-escalatory.

Modern combat direction systems (CDS) make use of several different stationary and mobile image generating sensors that constantly deliver raw image material to be evaluated in a ship's combat information center (CIC). As environment, sight and weather conditions vary, so does this material concerning its quality. Infrared (IR) sensors, for instance, deliver a significantly inferior signal-to-noise (S/N) ratio and are responsive to environmental conditions such as temperature and humidity. Hence the analysis of contained details and information can become exceedingly difficult and time consuming, if accomplished solely by human operators on their own. But given the busyness of merchant waterways nowadays, time is a very limited asset.

Consequently, an advanced support system is needed to guarantee a quick and reliable classification and identification of observed COIs. The Helmut Schmidt University of the Federal Armed Forces in Hamburg (HSU-HH) established the basis for such a system by developing two effective algorithms. They were tested extensively at the Bundeswehr Technical Centre for Ships and Naval Weapons (WTD 71) in Eckernförde and both proved to be reliable and accurate (Römer, 2001). German navy's KEOD (classification by means of electro-optical data) project was arranged to prepare and execute the deployment of a support system that is based on these algorithms.

There are already a lot of complex systems to be operated in modern CICs. Therefore a newly added support system should be as easy to use and as easy to learn as possible. Because the user interface built around the algorithms for testing purposes by HSU-HH and WTD 71 does not adhere to any ergonomic guidelines, the study UNbiS (user support concept for the application of optical sensor imagery for the classification and identification during surface reconnaissance) aimed at developing an optimized graphical user interface (GUI).

2. Decision support algorithms

The two algorithms (Günther et al., 1996) that constitute the core of the support system were developed at the HSU-HH. One performs investigations of object contours (contour classifier), whereas the other one investigates the relative locations of visible marks (marks classifier). Both deliver result lists containing the ship classes that have most in common with the analyzed data. A third algorithm has been developed within the UNbiS study, addressing the need for a means do deal with incomplete pictures and almost certain information (supplements classifier).

2.1 Contour classifier

This classifier needs the outer contour of the object to be classified (OTBC) and the information whether it has its bow left or right on the image as input. The classifier compares the OTBC with reference silhouettes of all known ship classes in the database. These silhouettes are supplied binary and were derived from 3D models picturing representative role, pitch, and position angles. The bow and stern positions in the contour of the OTBC are fitted into the binary reference matrix so that the silhouette’s length is standardized.

To assign the data at hand to the most probable reference objects, an average-free normalized cross-correlation function is used, whereupon movements in x and y directions are performed until a maximum correlation coefficient is found. Sections where lines are close-by but not exactly one upon the other are accounted for devalued. In the final step, the result list is sorted according to the correlation coefficients so that the ship with the most similar contour heads the result list.

2.2 Marks classifier

As input, this algorithm needs horizontal and vertical positions of visible marks on the image at hand as well as the rotation angle around the y axis. The system’s database contains the same data for all known ship classes. The classifier compares the data of the OTBC with that in the database. This is achieved by accumulating scaled Euclidean distances between OTBC and presumably corresponding database mark positions. The visibility of the individual ship parts with different position angles is considered, so that erroneous assignments of hidden ship parts are impossible.

The operator’s statement that a particular mark can be seen at a certain position is dealt with in a fault-tolerant way. Each pair of ship parts is allocated a confusion probability, from which a coefficient for the respective Euclidean distance is derived. The database ship classes are listed according to their total distance to the OTBC, so that the ship class with the most similar marks heads the result list.

2.3 Supplements classifier

The supplements function is similar to a filter, but not as rigorous. It does not exclude anything, but rather substantially reduces the score of any ship class that does not match the given criteria. The magnitude of the reduction depends on how many facts diverge. This approach guarantees that candidates figured out by one or both of the other algorithms are not ultimately removed from the result set due to wrongly assumed supplements. However, unlike with the other classifier algorithms that are highly fault-tolerant, in result lists ship classes degraded by this means will be found well below those that fit all criteria. It is a powerful tool to get rid of unwanted candidates at the top of the result list, but is to be used carefully.

3. User focused approach

The major goals of the work were to design an ergonomic operating concept and to realize a user support system. With the design of the system, in order to keep operators in the loop during reconnaissance missions, the main focus was on an efficient handling of the tasks to do, an optimized graphical user interface, and clearly guided operating sequences (Schweingruber & Brütting, 2004). Therefore, several discussions with experts as well as surveys of the procedures aboard took place.

The support system is based on an earlier concept that was designed to especially suit for an EO and an ISAR sensor aboard one particular naval unmanned aerial vehicle (UAV). With the new approach, imagery from all kinds of optical sensors on any platform shall be dealt with. The earlier concept had been evaluated using a demonstration and testing facility, too, and the lessons learned (Schweingruber & Brütting, 2003) have been incorporated into the new concept.

It was decided to deploy the new system on a standard desktop PC with flat screen display, mini keyboard and mouse. For the contour classifier, operators will have to draw the silhouette of the OTBC. This task would be too difficult and time consuming with a roll ball, the input device usually preferred on moving platforms. Experimentation with a special test-bed for naval anti-air warfare (Mooshage et al., 2003) has shown that standard mice are highly accepted and well suited for support systems in naval environments (Grandt et al., 2003). An argument often put forward in favor of roll balls is that they are relatively robust against ship movements, as compared to mice only loosely connected by a cable. However, by taking adequate measures undesirable mouse displacements can be prevented. Furthermore, most people are already trained with mice.

Beginning with sensor imagery at the one side and the reliable algorithms described above on the other side, an ergonomically optimized GUI had to be designed. To guide users through the steps necessary to feed the algorithms with data and to interpret the results, a sequence of clear cut process states (Figure 1) has been developed in cooperation with subject matter experts. In every process state, only information that is needed to fulfill the particular subtask is displayed (Mooshage & Schweingruber, 2005).

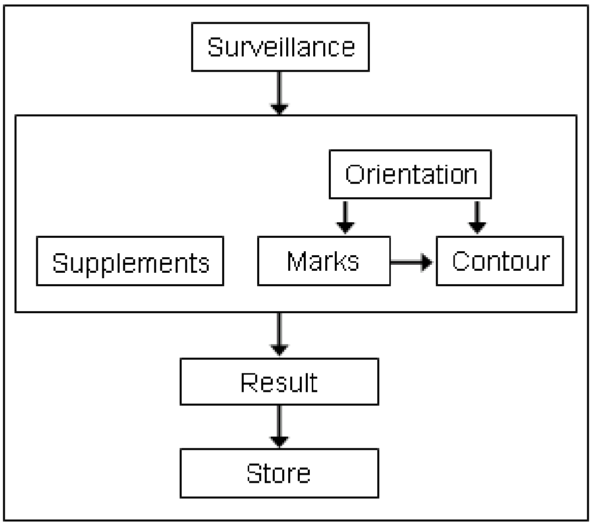

Figure 1: States of the support concept

The new support system is implemented in the modern and reliable programming language Java. A graphical development environment is used that allows quick testing of the semi-manufactured product. GUIs that lack an understanding of the presumable operating procedures tend to be functionality-oriented and hence difficult to use and difficult to learn, which is also the case with the former provisional interface. According to the philosophy of rapid prototyping, subject matter experts, namely those operators in the ship's CIC assigned to analyze the results of optical reconnaissance, were frequently asked to examine the system and give feedback, based on which it could be optimized and enhanced. In the beginning, expert talks mostly took place ashore. Main partners were from Naval C2 Systems Command (KdoMFüSys) in Wilhelmshaven and the Federal Office of Defense Technology and Procurement (BWB) in Koblenz.

Of capital importance in terms of the user focused approach were the evaluations under realistic circumstances onboard several different naval vessels. The first tests aboard took place at about half time of the study. They yielded a high quality system that was already prepared to serve aboard. At the end of the study more onboard evaluation was conducted, that allows further optimization and amelioration to be realized within the follow-up study.

4. Graphical user interface design

This chapter introduces the support system as of March 2006. Several details are based on ideas originating from the first experimentation campaign. Other ideas came from early discussions with subject matter experts from different naval offices. Rapid prototyping allowed quick preliminary implementation of supposed additional features, so that ideas could be evaluated and concretized.

Figure 2: The four quadrants of the GUI – process state Surveillance

4.1 Overall structure

To make it easy for operators to find required information and functionality, throughout all process states the overall layout is constant. The GUI is subdivided into four quadrants (Figure 2) that stand for different subject areas (Schweingruber & Mooshage, 2005).

The 1st quadrant always contains imagery originating from the attached sensor. Depending on the process state currently performed, different manipulations can be made within this image.

The 2nd quadrant is reserved for controls belonging to certain tasks. The contents of this area change according to the process state that is selected.

In the 3rd quadrant, the overall controls can be found. This area consists of buttons to go to another process state, to load, save and store classification results, as well as to change the language used by the system, to change the colors between day-light and darkness mode, and to shut down the system.

In the 4th quadrant, there is a database viewer in which all known ship classes can be browsed through. It is possible here to look at reference pictures, outline drawings, VRML models, as well as facts and data of all ship classes in the database. The sub database choice function, which allows reducing the search space to a dedicated selection of ships, is also located in this quadrant.

Figure 3: 4th quadrant with sub database choice open

This filter (Figure 3) has been implemented after the first experimentation campaign taking into account the voiced wishes of the subjects. Available selection criteria are nation, length and draft. The resulting collection can be modified by adding and removing specific classes. Manually removed classes that would be in the collection based on the selection criteria are listed with strikethrough, which is based on the idea of a subject in the second experimentation campaign.

4.2 Process states

4.2.1 Process state Surveillance

In process state Surveillance, the operator’s task is to choose appropriate imagery from the available material. A time-bar allows reviewing what has been recorded within the past few minutes. Through buttons that are similar to fast backward, fast forward, single image back, single image ahead etc. on typical remote controls or simply by clicking at any position in the time-bar it is possible to navigate the available imagery easily. Images can be further optimized by zooming and manipulating brightness and contrast. Once the operator has decided which image to take, the next process state can be selected.

The button that shows a rabbit has been added based on operator complaints that the whole classification sequence is quite long. It provides a shortcut that allows skipping some memory organization tasks.

4.2.2 Process state Orientation

Process state Orientation provides graphical support for the ascertainment of the rotation angles on all three axes, because both classifiers need information about the object’s spatial orientation on the chosen image. In the 2nd quadrant, a model ship can be rotated to the appropriate position. It is possible to choose among three different ship types, so that the model is somewhat similar to the OTBC seen above. However, it is not intended to have more ship types for choice, lest operators waste too much time for choosing.

4.2.3 Process state Contour

In process state Contour, the object’s shape is supplied. The operator is asked to do that within the sensor image area in the 1st quadrant. It can be performed by inputting points that are connected by a polygon, by completely painting, or any combination of both. A preview line between the last clicked point and the current mouse position always indicates how it would look if clicked now.

By clicking the right button of the input device, points can be removed. Painting can be removed by holding that button and moving the device, whereat the motion speed determines how fast painted sections are taken away. The 2nd quadrant provides undo and reset buttons as well as a button to close the polygon, so that it is not necessary to exactly hit the starting point again. This function is particularly valuable in combination with a high sea state. Based on an idea of a subject in the second experimentation campaign, it is automatically invoked when the contour is saved.

4.2.4 Process state Marks

Within process state Marks, the operator is asked to input the identifiable marks. If process state Contour has not been completed before, it is necessary to highlight the frame of the OTBC first, otherwise it is derived form the silhouette. In the 2nd quadrant, a list of all position dependant marks such as bridge, turrets, masts etc. can be found. After a mark has been chosen, its position must be clicked at on the image at the 1st quadrant. An erroneously entered mark can be removed by placing the cursor nearby and clicking the right button. Therefore the temporarily nearest mark is always highlighted by a circle. Furthermore, an undo button allows removing the mark entered last, a remove button to remove all of a kind and a reset button to forget about all of them. It is not necessary to always move the cursor to the menu below the image to change to another kind of mark. By clicking the left or right button outside the frame, the next or previous line of the marks list is selected. The marks are sorted as they typically appear from bow to stern. In addition to the position dependant marks, there are more marks whose positions are not relevant, such as helicopter-deck, because they are too huge to be assigned to a particular position. These marks can be found in a list of their own alongside the position dependant marks. For each of these marks it can be denoted whether or not it is visible via check box.

4.2.5 Process state Supplements

Process state Supplements can be used to incorporate any almost definite information into the classification process. If, for instance, the length of the OTBC can be estimated quite exactly, ships that are significantly shorter or longer can be neglected. Other criteria are any kinds of marks, nation, form of bow and stern, part of hull number, and ship grouping (Figure 4). Supplements can be used in addition to other algorithms or as stand-alone classifier.

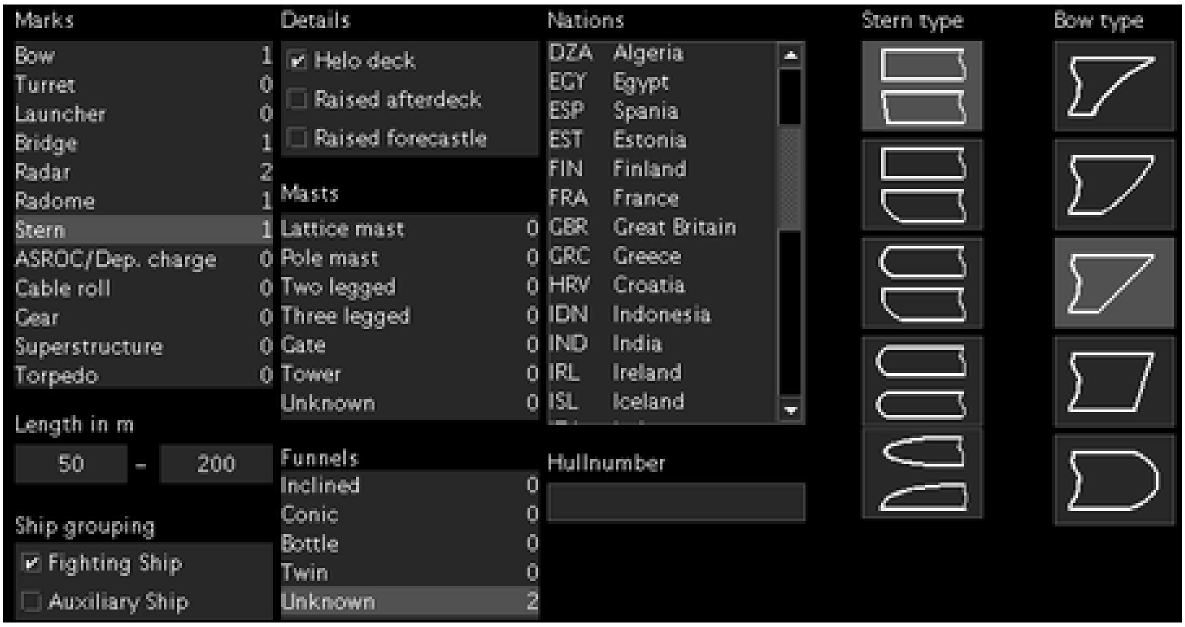

Figure 4: 2nd quadrant in process state Supplements

4.2.6 Process state Result

Finally, process state Result presents a list containing the most probable ship classes as figured out by algorithms and supplements function and offers several opportunities to compare the material at hand with reference imagery, outline drawings, 3D models, and data records. The database viewer at the 4th quadrant changes its appearance, so that 3D model, outline drawing and the reference image with the most similar rotation angle of an entry selected in the result list can be seen in maximum size directly alongside the chosen original sensor image. It is important that the operator performs a visual comparison, because the scope covered by the algorithms is limited and humans have different skills as to pattern recognition. Once the operator has found the entry within the result list that seems to equate the OTBC, the decision can be saved. It is possible to add comments in written and spoken form, so that another operator investigating the material can be told the circumstances of the classification, e.g. why there was a particular interest in that special object.

4.2.7 *Process state Store*

Process state Store is not directly connected to the classification sequence. The amount of stored classifications is likely to increase quickly when vessels are, for instance, deployed to sea area monitoring operations. To ease the handling of such material, this process state provides a concise table that is sortable according to many different criteria. The store can be burned on CD or DVD to enable the crew to send it to naval command for further analyses.

5. Evaluation

Testing under realistic circumstances is of course a part and parcel of user focused development. Besides performance, reliability and stability of the system, acceptance and utilization by navy personnel is of paramount importance. Experiments under realistic conditions are particularly valuable to find out about the two last mentioned. The nearly finished system has been tested on several different seagoing vessels.

5.1 Evaluation methodology

The test procedure was designed based on navy specific requirements in consideration of tactical conditions. Limiting the group of test persons to seagoing personnel guarantees a homogenous collective with appropriate education and training as well as the most up to date experience. In the experiments, navy personnel got a standardized personal introduction to the system and its functionality. Then the operators observed an exemplary classification process run by the investigator before they had to work on realistic scenarios on their own.

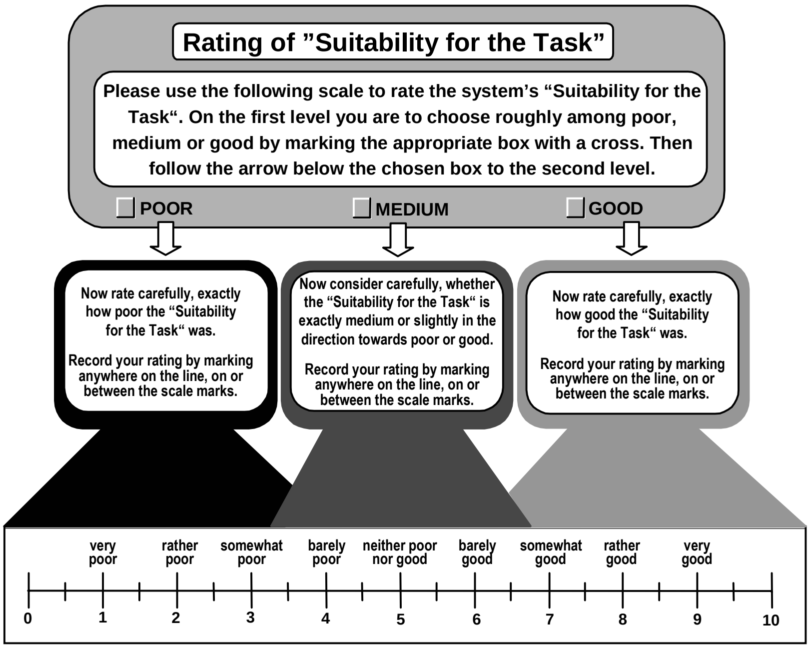

Figure 5: ZEIS rating scale for quality of suitability for the task

To evaluate the effectiveness of the system, an extensive questionnaire was designed that subjects had to fill in directly subsequent to the experiment. The questionnaire consists of rating scales and questions. Test persons were asked to rate certain qualities of the system by means of the 2-level rating scale called ZEIS (Pitrella, 1989). On the first level, a relatively raw decision has to be made among poor, medium and good. On the second level, a finer differentiation takes place on an 11 point scale with adequate descriptions (Figure 5).

The main advantages of subjective rating scales are that they are well accepted by test persons, highly valid and provide hints for system development (Pfendler, 2000). The rating scale is used to review the system in regard to the five criteria suitability for the task, self-descriptiveness, controllability, conformity with user expectations, and error tolerance.

These ergonomic criteria are defined in the international standard DIN EN ISO 9241-10 (DIN EN ISO 9142-10, 1996) as follows:

Suitability for the task: A dialogue is suitable for a task when it supports the user in the effective and efficient completion of the task.

Self-descriptiveness: A dialogue is self-descriptive when each dialogue step is immediately comprehensible through feedback from the system or is explained to the user on request.

Controllability: A dialogue is controllable when the user is able to initiate and control the direction and pace of the interaction until the point at which the goal has been met.

Conformity with user expectations: A dialogue conforms with user expectations when it is consistent and corresponds to the user characteristics, such as task knowledge, education and experience, and to commonly accepted conventions.

Error tolerance: A dialogue is error-tolerant if, despite evident errors in input, the intended result may be achieved with either no or minimal corrective action by the user.

Although these criteria are analysis oriented and do not contain any advice on how to deal with design conflicts, they provide an accredited assessment framework. Augmenting this norm that specifically applies to dialogue design, comments on the standards (DATech, 2006) give advice for whole systems. In addition to filling the rating scales, subjects have to answer questions on what in particular displeases them and what appeals to them, so that system designers not only know where deficits are but also get hints on how to address them.

5.2 Latest experimentation campaign

The results of the first experimentation campaign conducted at about half time of development in November/December 2004 are described in detail in earlier papers (Mooshage & Schweingruber, 2005; Schweingruber & Mooshage, 2005).

The system, already optimized and enhanced based on the findings of the earlier experimentation, was evaluated again during SEF (standard mission training task group fleet), which is the most important annual exercise of the German navy. It took place in the Baltic Sea in September 2005. Besides the German participants, Scandinavian and East European navies as well as NATO task group SNMG1 (Standing NATO response force Maritime Group 1) were involved. The exercise was based on a complex geo-political scenario and consisted of a phase with guided exercises and a free-play phase.

Tests took place onboard several German vessels, namely tender Donau (A 511), fast patrol boats S71 Gepard (P 6121), S76 Frettchen (P 6126), S73 Hermelin (P 6123), frigate Hamburg (F 220), and frigate Köln (F 211). Although a lot of ideas originating from the first experimentation campaign had already found their way into the system, again many subjects mentioned potential details to augment and enhance the user support system in their questionnaires as well as in personal discussions with the investigator whereof examples can be found in the criticism below.

5.2.1 Tender Donau

The questionnaire was filled out by 9 subjects. The results of the rating scales are as follows:

Suitability for the task: poor 0, medium 1, good 8. On the finer second level of the rating scale, suitability for the task was rated an average value of 7.6 with a standard deviation of 1.65. One subject suggested adding a functionality to reverse image colors, because it might be easier to spot the contour then.

Self-descriptiveness: poor 0, medium 4, good 5. On the finer second level of the rating scale, self-descriptiveness was rated an average value of 6.9 with a standard deviation of 0.79. It was criticized that there is no online help. An online help is currently being implemented and will be part of the next version of the system.

Controllability: poor 0, medium 1, good 7. One operator felt unable to express an opinion. On the finer second level of the rating scale, controllability was rated an average value of 7.8 with a standard deviation of 0.41. There was no concrete criticism.

Conformity with user expectations: poor 0, medium 1, good 7. One operator felt unable to express an opinion. On the finer second level of the rating scale, conformity with user expectations was rated an average value of 7.5 with a standard deviation of 1.00. It was proposed to add more feedback when the operator has to wait while the system is loading or saving data.

Error tolerance: poor 1, medium 2, good 6. On the finer second level of the rating scale, error tolerance was rated an average value of 6.6 with a standard deviation of 2.32. There was no concrete criticism.

5.2.2 Fast patrol boats S71 Gepard, S76 Frettchen and S73 Hermelin

The questionnaire was filled out altogether by 13 subjects. The results of the rating scales are as follows:

Suitability for the task: poor 5, medium 2, good 5. One operator felt unable to express an opinion. On the finer second level of the rating scale, suitability for the task was rated an average value of 5.6 with a standard deviation of 2.74. Some subjects found the time needed to make necessary inputs too long; many asked for the contour to be deduced automatically. It was also said that the GUI is not comparable to any system aboard, because it is much more versatile, substantial and user friendly.

Self-descriptiveness: poor 1, medium 7, good 5. On the finer second level of the rating scale, self-descriptiveness was rated an average value of 6.3 with a standard deviation of 1.79. It was praised that having listened to the instructions there were hardly any difficulties in using the system.

Controllability: poor 0, medium 2, good 11. On the finer second level of the rating scale, controllability was rated an average value of 7.7 with a standard deviation of 0.65. One subject gave the opinion that drawing the contour might be easier with a touch screen monitor.

Conformity with user expectations: poor 0, medium 5, good 8. On the finer second level of the rating scale, conformity with user expectations was rated an average value of 7.0 with a standard deviation of 1.51. It was criticized that the control step to close the filter is different from the one used otherwise.

Error tolerance: poor 4, medium 4, good 5. On the finer second level of the rating scale, error tolerance was rated an average value of 5.4 with a standard deviation of 2.70. There was no concrete criticism.

5.2.3 Frigate Hamburg

The questionnaire was filled out by 19 subjects. The results of the rating scales are as follows:

Suitability for the task: poor 0, medium 1, good 18. On the finer second level of the rating scale, suitability for the task was rated an average value of 8.0 with a standard deviation of 0.67. It was criticized that the operator had to push a button to close the contour polygon before being able to save it. The functionality has been changed in the meantime so that the polygon is automatically closed when saving. Furthermore it was proposed to add a so-called operator library for ships that are sighted but not yet in the database. Two subjects suggested augmenting nation lists with little images of nations' flags.

Self-descriptiveness: poor 0, medium 8, good 11. On the finer second level of the rating scale, self-descriptiveness was rated an average value of 7.3 with a standard deviation of 1.37. Two subjects mentioned that there are no warnings before irreversible actions are executed. Both proposed retaining that unchanged, because they find the typical dialogue windows annoying. One subject proposed some minor changes to make the filter more concise, all of which were implemented in the meantime.

Controllability: poor 0, medium 7, good 12. On the finer second level of the rating scale, controllability was rated an average value of 7.2 with a standard deviation of 1.41. It was suggested that it should be possible to rotate VRML models at any time.

Conformity with user expectations: poor 0, medium 3, good 16. On the finer second level of the rating scale, conformity with user expectations was rated an average value of 7.8 with a standard deviation of 1.18. Some subjects asked for scores with the result list, but this piece of information is intentionally not given because it would reduce the weightiness of human visual comparison.

Error tolerance: poor 1, medium 3, good 14. One operator felt unable to express an opinion. On the finer second level of the rating scale, error tolerance was rated an average value of 7.4 with a standard deviation of 1.83. There was no concrete criticism.

5.2.4 Frigate Köln

The questionnaire was filled out by 22 subjects. The results of the rating scales are as follows:

Suitability for the task: poor 0, medium 8, good 14. On the finer second level of the rating scale, suitability for the task was rated an average value of 7.5 with a standard deviation of 1.20. It was praised that the complete functionality of the system can be reached by mouse. Many subjects asked for the contour to be deduced automatically or for means to reduce the time needed for manual input. Furthermore it was proposed to add an operator library.

Self-descriptiveness: poor 0, medium 7, good 15. On the finer second level of the rating scale, self-descriptiveness was rated an average value of 7.4 with a standard deviation of 1.32. It was praised that images can be deleted without a query dialogue.

Controllability: poor 0, medium 2, good 20. On the finer second level of the rating scale, controllability was rated an average value of 8.0 with a standard deviation of 0.91. It was proposed to add functionality to increase speed of fast forward and backward as well as to make single image back and ahead repeat buttons.

Conformity with user expectations: poor 0, medium 7, good 15. On the finer second level of the rating scale, conformity with user expectations was rated an average value of 7.7 with a standard deviation of 1.44. It was criticized that there is not enough feedback when the operator has to wait while the system is loading or saving data.

Error tolerance: poor 1, medium 7, good 11. Three operators felt unable to express an opinion. On the finer second level of the rating scale, error tolerance was rated an average value of 6.9 with a standard deviation of 1.84. There was no concrete criticism.

5.3 Discussion

The ZEIS results are very good for the frigates, where operators have most experience with out of area missions and sightings of vessels they have never seen before. Fast patrol boat operators typically stay within nearby sea areas like Baltic and North Sea and know very well which vessels to expect. Probably that is why the acceptance of the system and consequently some of the ratings are a bit lower.

On the other hand, average score mostly goes together with relatively high standard deviation which means that there was controversy. Operators were asked to rate the system as a whole, not only the GUI. For example, a typical complaint with suitability for the task was that the contour of the OTBC should be deduced automatically. Some subjects even alleged that they knew about graphics software capable of doing this job, but experts from the Research Institute for Optronics and Pattern Recognition (FOM) in Ettlingen say that the task, given the differences in type and quality of the available imagery, is extremely challenging.

The second experimentation campaign, just like the first one before, made for lots of ideas on how the system could be optimized and enhanced. Many of the useful ideas of the first and some of the useful ideas of the second campaign have already found their way into the system as it is described in this paper. Some suggestions are very ambitious, such as the often demanded automatically deduced contour and the operator library. It is planned to deal with both these challenges within the next study.

6. Conclusion and outlook

During the development of the new user support system GUI, the main focus was on an efficient handling of the tasks to do, an optimized graphical user interface, and clearly guided operating sequences. The evaluation phase with the trials at sea has reconfirmed that the system provides substantial support for image analysis as well as object classification and identification.

Within the follow-up study, which is called UKIDuO (support for classification, identification and data acquisition of civilian and unconventional objects), it is planned to investigate potentials for classification applications broader than naval vessels, with a special focus on unconventional combatants and asymmetric threats. In addition, the suggestions gathered in the latest experiments will of course be used to further enhance the support system.

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