Alarm Management in a Robotic Winery

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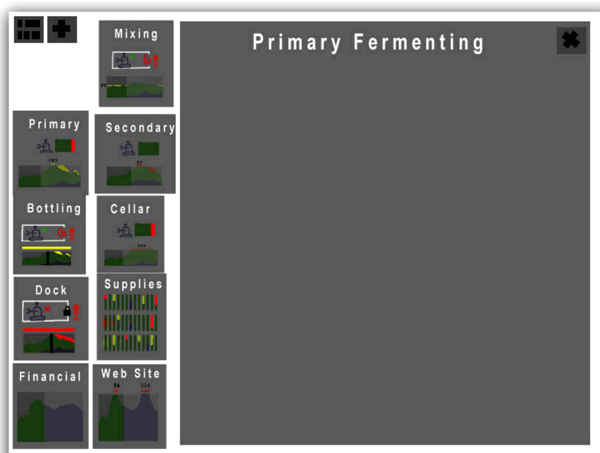
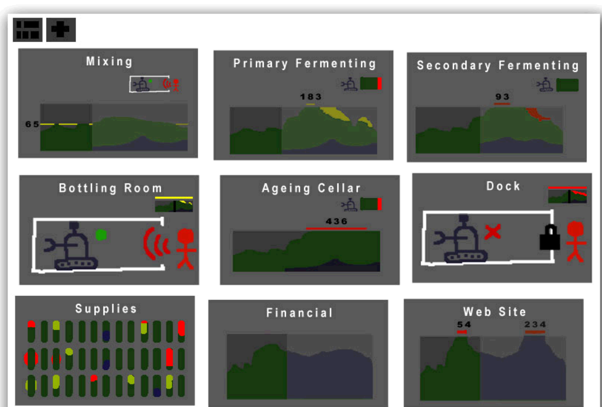
This preliminary design is for a control system to monitor the use and system performance of a do-it-yourself robotic winery with the purpose of maximizing the use of system components and reducing costs. The operator of the winery, the individual responsible for renting out the equipment to make wine, should have at hand the tools required to make informed decisions. The premise of the interface is to give this operator an accurate yet understandable representation of the resources and states of the facilities. Using the techniques of functional decomposition, forms of representation, maxims of relevance and salience this interface presents thousands of points of data as an understandable unified information environment.



Conceptual Design

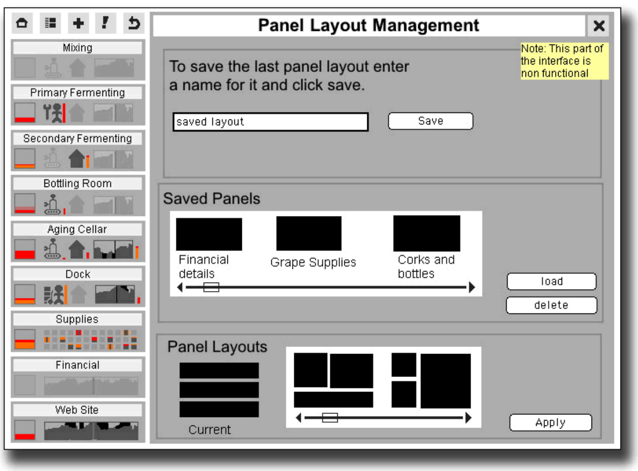
The initial designs were concerned with the display of information and the navigation between elements. This preliminary design focused on an overall monitoring screen, showing the nine separate areas involved in ensuring smooth operation of the winery, and a single blank detail screen from one of these areas.

The overall monitoring screen is a grid of nine areas. The first two rows are physical areas in the factory and the last three are conceptual data representations. At this phase in the design, the factory areas have two data representations that can alternate. One represents the state of the robotic and automation systems and the other represents the usage statistics. Clicking on the smaller representation will switch its position with the larger one. This feature was removed at a later



stage of the project since this prevented interaction with the data in other ways. The design now allows the user to drag these summary data points to a blank window or the "plus" icon which will give more detailed information and access to the single sensor data.

At the start of the design, the form of the display took on the characteristic of the winery itself. The data self organized into nine packages. This benefits the operator by perceptually segmenting the information into easily interpretable portions. Some features were developed to help users navigate down into the single sensor data displays beneath the overall system performance display of these nine areas. The workspace of a multiple panel environment was chosen so that the overlapping of windows would not hide essential information. This essential information was deemed the health meters of the nine main sections of the winery. These nine sections were used as visual momentum to preserve a constant base in the side bar where the overall health could be monitored at all times. The configurable display of comparable sensory data from either supplies or the fermenter environment or hours of use of the robots was included in the design with the ability to open the summary data to reveal the multiple points of sensory data. A method of storing these views was added so that relevant comparisons could be stored and recalled later. This helped define the workspace in which the operators could customize and store views.



Design Phases

Limited inspiration was garnered from the classmate evaluation and the presentation. The presentation was of limited value due to the difficulty of imparting the complexity of the interface in the allowed presentation time. This situation did not develop enough understanding of the design issues in the reviewers to stimulate proper discussion. As well, the classmate evaluation was of limited value and this could have been due to the lack of understanding or limited transfer of design background. Ideally, a peer review board should have been used at each of the project phases, from design concept and functional decomposition to the final redesigns. This would develop a panel of informed reviewers that could have quickly and effectively given feedback rather than presenting to uninformed commentators.

The three most catalytic phases in the design process were the functional decomposition, the building of the prototype and the usability test.

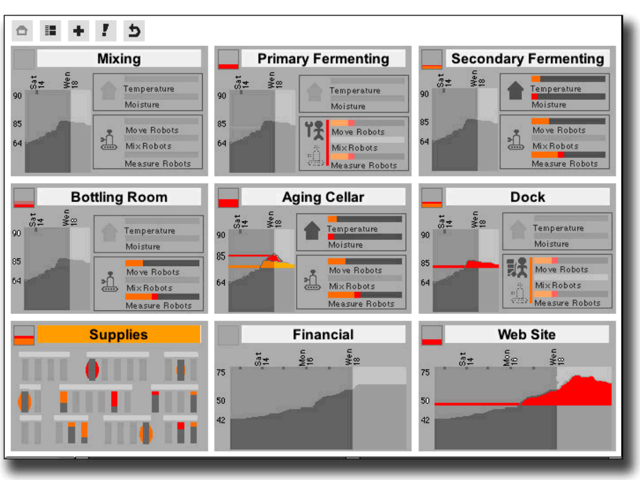
The functional decomposition has produced several relevant relations amongst the data that can be gathered throughout the process and as well from the feedback of the vintners.

The decomposition would be further expanded as elements and procedures that have been overlooked are exposed. As the design evolves, new elements can always be crosschecked to ensure that there is a relation up the hierarchy to the primary functions of the system. The main attribute that the functional decomposition revealed was the amount of detailed information that should be available but must also be summarized. This stimulated the design of summary information displays and an alarm management scheme.

More details of the design were revealed in the prototyping phase. Conceptual ideas reveal their weakness and complexity when faced with the cold reality of having to function. As many design decisions were made when prototyping as when analyzing other information. The initial concept of a robotic winery was prototyped to gather feedback and perform primary usability testing. The testing prototype encompassed a distinction between active and acknowledged alarms as well as the distinction between warnings; indicating the possibility of loss in the future, and alerts; indicating an immediate loss of revenue or denial of service to a customer. This main concern of the prototype was to determine the efficacy of the alarm manager in helping the operator problem solve by simplifying the task of selecting a focus and by making it easier to prioritize actions.

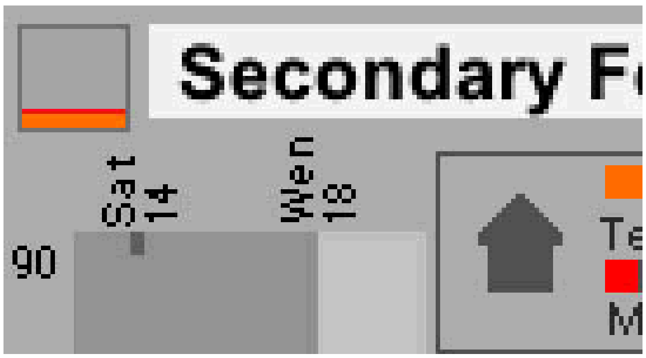
The usability test was a formative evaluation. The design was at an early stage and explored ideas so the emphasis of the testing was to stimulate opinions rather than measuring performance.

While the designs were germinating, the massive amount of data that needed to be available to the operators revealed it self. With the principle of showing information rather than data it was determined that one of the prime functions of the operator will be to sort through the data to find anomalies. Therefore, the premise of showing alarms came from the principle of mapping (Woods) and the idea of bringing attention to interesting data by highlighting anomalies. As the design was developed the need to bring attention to anomalies was realized as summaries of individual data points where distilled into an integral display. How can you highlight anomalies when the data has been summarized into a simplified health meter? In a mass data display such as the supplies area, where all the individual supplies are represented, it would be possible to highlight anomalies. When the panel is closed and only a summary of it is available then a different method of highlighting must be used. When the amount of information displayed at one time prevents the possibility of highlighting a specific anomaly then an abstract way to indicate an anomalous event should be used.

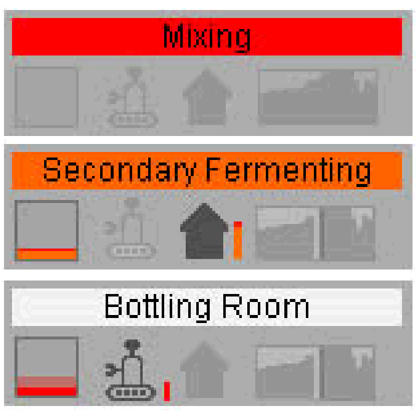


In this case, an alarm was designed.

Since the data cannot be highlighted then the health meter had to be used as a way to show anomalies. If the anomalies just accumulated as more red or more yellow in the heath meter then this method of informing might go unnoticed for several reasons. Salience is very low if there is already an accumulation of red in the area. As well, the operator may not be there or may be distracted with some other task when the anomaly arises. This was why a separate display area for an unacknowledged anomalous event was developed. The combination of the health meter and the coloring of a title are ways in which alerting can be used to bring attention to an anomaly while the health meter can be used to maintain in essence a highlighting of that anomaly.

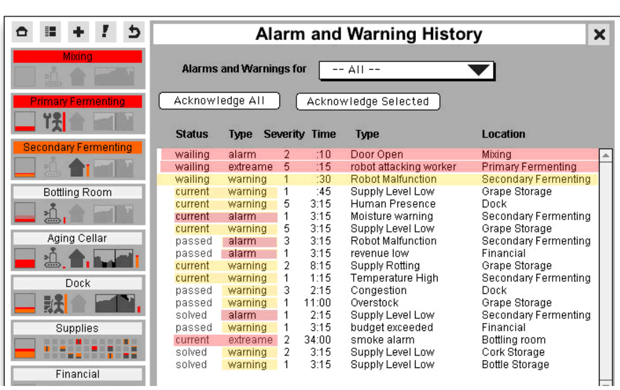


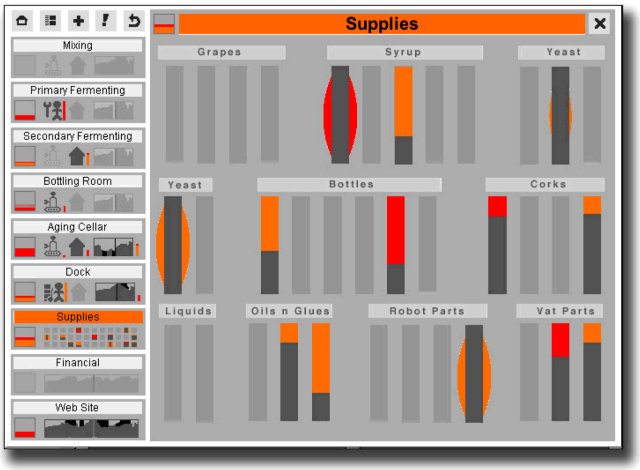
How this alarm distinguishes itself is based entirely on salience and how to represent the degree of the problem. This difference in salience amongst alarms adds meaning to the alert and helps the operator prioritize. The alerts are categorized into three types with a "warning" meaning a possible loss in future, an "alarm" meaning a loss or denial of service to a customer and an "extreme alarm" meaning a hazard to person or property.



As well, the statuses of these alarms can be at three possible levels: active, where the alarm is currently going off; acknowledged, where the alarm is going off but the operator has chosen to ignore it; and solved, in which case the situation has either been resolved or is no longer a problem.

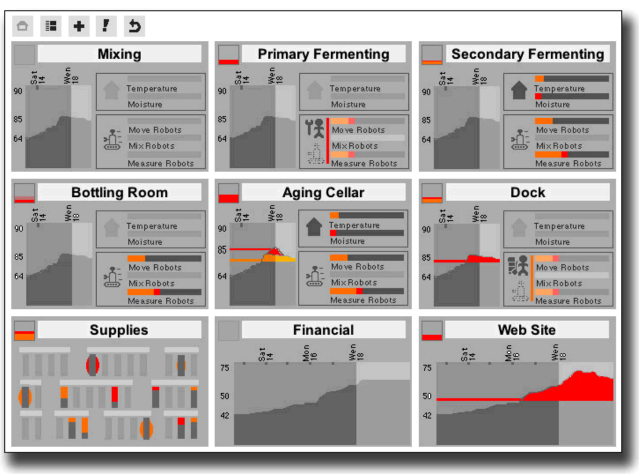
Once this alarm information is organized and treated as another data point then the entire mapping criterion re-applies to the highlighted anomalies. Is there a change in the alarms over time? Is there a rate of change of the alarms? Is there an unexpected alarm? An alarm showing a low level of a supply soon after ordering may indicate a leak. This type of historic data of alarms was collected into the alarm manager. It was in this part of the interface that Grice's maxims of relevance was, to put it bluntly, very relevant. How do the alarms relate to each other and how many have there been? This type of information put a frame of reference around the single data point of an alarm. This adds the needed context with which to interpret an alarm.





Most of the design looked at very high-level concepts such as navigation and alarm salience. This was due to the overwhelming availability of data from the nine sections of the winery. The one section that was developed is the supplies area where the usability test looked at navigation. It was here that a mass data display was used to show every possible type of resource and the status of the supply. This mass data display is good at fault detection and so is appropriate in this supplies area but would probably not be used in other areas since it does not help in fault resolution. Supply problem have a simple solution and would not need a more refined form of data display.

The design compiled the details of the individual sensory data are into three representations. The first is a usage graph of the resources in that area that is shown in the analogical form of a historic value graph that can give context to whether the efficiency is improving or failing. The second, combines analog and iconic forms and shows the status of the robots as an icon and the general health of the group in a bar graph. The third representation also combines analog and iconic forms and it shows the status of the environment in that area.



Issues exposed in the Usability Study

The primary function of the alarms and the variation in salience of them worked well by attracting attention to the most sever problem. The subjects all went to most extreme alarm and it was noticed that the alarm summary was not an obvious area to go to determine interrelation amongst events.

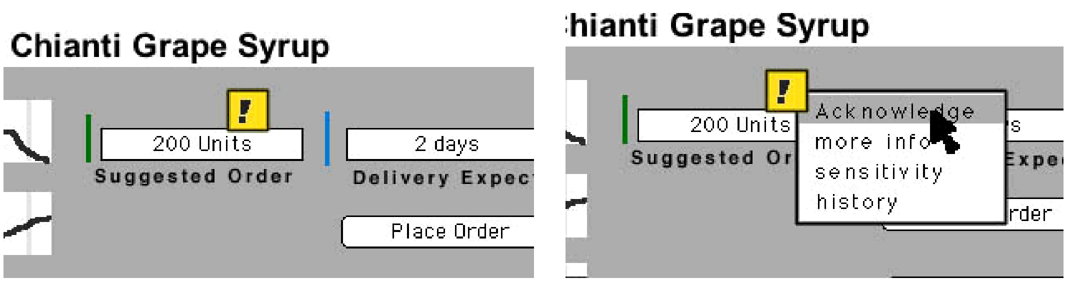
Redesign Based on Usability Study

The formative usability study inspired the most design changes.

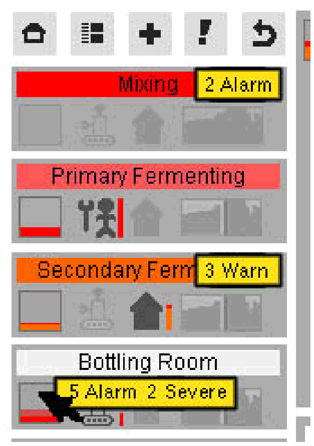
(1) The salience of extreme alarms should be set by the user using a slider to determine the speed of flashing for extreme alarm situations.

(2) The size of the coloured alert areas in the supplies panel does not map to the severity of the alarm. It would be more effective to change location of the coloured alert to the boundary between the empty and full parts of the bins.

(3) Auto acknowledgement of alarms should be removed so that when an alarm is shown it should stay active. The acknowledgement distinction is not whether the user sees the alarm but rather whether they have made the active choice to deal with it or not. A switch to acknowledge or activate the alarm should be placed close to where the source of the problem originates. This will act, as was determined from the users comments, as a "to do" list enabling the operators to prioritize problem by whether their alarms are active or acknowledged.

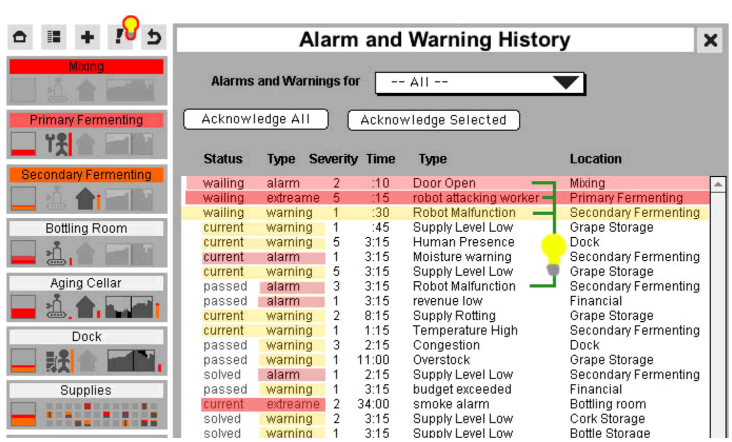


(4) The audio warning associated with the alarms should be a separate setting that allows the user to be informed of new alarms while away from the terminal but be able to silence them while actively using the interface.

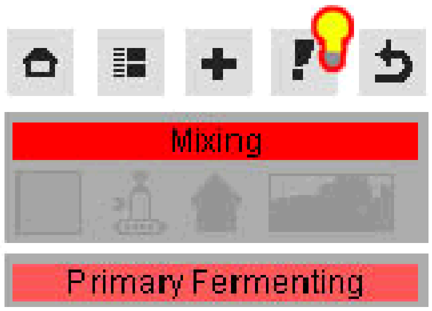


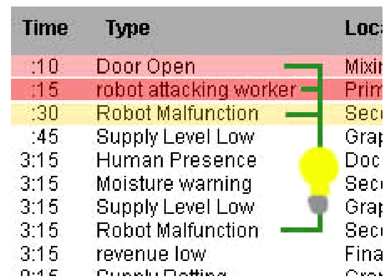
(5) An indicator for the number and type of alarms in an area should be designed for the situation where multiple simultaneous alarms occur in the same area. The solution could be an indicator in the title area of the panels showing the number of alarms and warnings in that area. The same information could be displayed in a rollover of the acknowledged alarms in the health meter.

(6) "Cause and effect proposals" should be added to the alarm manger to show possible cause and effect relationships between alarms or with other information. An icon could be added to the alarm manger button to attract attention to it when multiple alarms activate



and the system determines that a relationship could be possible.





The yellow light bulb icon is used to attract attention to the alarm manager. The green lines show a possible relationship. Clicking on the light bulb will give the operator more details as to why the system determined there was a relationship.

(7) Finally the salience of non-alarms, where the areas of the winery are grayed out if there are no alarms active, should be redesigned to allow for user control by added a slider to determine the level of graying out of non alarm situations. This redesign suggestion came about, not through the evaluation of a task but indirectly, when describing how the alarm manger shows a list of alarms that might interrelate. In some situations, non-alarms could interact with alarms and so the salience might be needed in some situations to compare alarm data to non-alarm data.

Remaining Design Work

Detailed Design

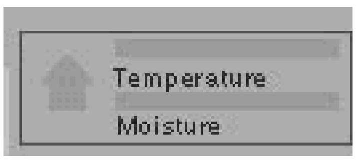
This interface is still in the formative stage of development. The details of the many single sensor data representations are still to be developed. The overall navigation design of the system seems to be solidifying. The display of an overall health meter of each section and the navigation within panels and the ability to compare has been considered but how this will work when real data and real situations develop is unknown and will have to be usability tested once a full design has been implemented in a prototype.

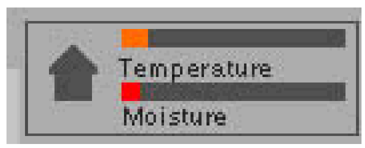
Social Considerations

This interface may be used by several operators at the same time with differing levels of expertise. A method with which operators could collaborate on problems would be a valuable addition to the system.

Aversion Therapy vs. Positive Reinforcement
If the alarms only bring attention to the problem then how will the operators know to improve the status quo? This is a paradox of alarms. The operators will be trained to do nothing when nothing is wrong rather than trying to improve the current situation. At present, the alarm management system creates a form of aversion therapy. The operators are expected to act when there is a problem. Solve the problem and the alarm goes away. The operator feels they have done their job. This is fine if you do not want the system to be in failing state but what can be done to encourage the operators to improve the system?

The design where non-alarm situations were grayed out to reduce their salience is a questionable design feature. It effectively conditions the operator to accept the status quo.





Just like people encouraging you when you do a good job, this system should also give feedback to the operators when particular areas of the winery function at better than expected levels. How should the interface enact positive reinforcement? Rather than just flashing red and screaming every time something is wrong, perhaps the interface should do something nice when things are going well.