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A framework for usability evaluation of automated driving human-machine interface in context of UAE

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Abstract
As a future mobility enabler, vehicle teleoperation offers a viable option for efficiently leveraging the benefits of driverless cars, whilst fully automated cars (SAE 5) are not completely viable. Despite the huge amount of research on self-driving technology, the notion of riding in a fully automated vehicle is still sceptical. Hence necessitating the presence of a remote operator who tele monitors the vehicle and acquire control in case of failure beyond the capabilities of vehicle automation, such as misuse, disuse or mode confusion and ensuring safety and reliability. Keeping the current inclination towards automated vehicles and the launch of the United Arab Emirates" (UAE) first driverless, autonomous 12-seater shuttle, the researcher has suggested a low-fidelity basic prototype. To connect the vehicle's automation and human teleoperation, the researcher has proposed a unique and interactive framework of Human-Machine Interface (HMI) to cater teleoperation in the context of automated vehicles (AVs) in the UAE. The design is optimised for the teleoperation of a highly automated shuttle by a public transportation control centre based on a logical and careful inquiry. After deriving a detailed analysis of requirements, a prototype is then created and refined until an interactive user-interface emerges. Fifteen control station experts are presented with a prototype for evaluation in a regular manner and solicited to work out three scenarios with disruptions in the system. The prototype is then evaluated using questionnaires and structured interviews. The results validate the suggested HMI design for the remote operation of a highly automated vehicle. Participants' feedback shows a particularly high level of satisfaction in terms of perceived capacity, feasibility, usability approval and situational responsiveness. The findings also provide valuable information for an advanced interactive HMI design and pave the way for potential future directions in further research as well.

Keywords: Autonomous vehicle, human-machine interaction, human-machine interface, usability study design

1. Introduction

Living in the era of Artificial Intelligence (AI), researchers are constantly investigating, exploring and utilising AI to improve the quality of human lives. Despite being challenging, automated vehicle technology, in this regard, has gained much popularity, as it is one of the most convenient and demanding applications in the field of AI. With the introduction of automated vehicles into urban traffic environments, the automation of driving tasks is progressing considerably, as drivers may be allowed temporarily to partake in other possible Non-Driving Related Tasks (NDRTs) while driving [1]. Having the ability to lessen the energy consumption of the drives, stress and pollution while growing road capacity, automated driving technology not only grants mobility to the unlicensed and, most significantly, increases road safety (Schoitsch, 2016; Litman, 2022) [12, 8]. Currently, human machine interface (HMI) systems represent an entirely new and immature technology, so it is important to carefully determine its usability, as there is still a long way to go before driving tasks are fully automated. Although, a significant body of research has been investigating the impact of varied HMI approaches subjectively, the results are inconclusive. Particularly regarding the urban traffic environments with multifaceted and complex driving manoeuvres and road users, which still need to be considered Bhavsar, et al., (2017) [5]; necessitating a concrete interface design solution Zhang, et al., (2021) [15].

Therefore, to do so, outsourcing the monitoring task of the driver's on board deck to a higher-level facilitator could be a possible pro-tem solution. Such as a control station that, if necessary, commands and remotely controls the vehicles to harness the potential of advanced automation without compromising road users' safety.

Teleoperation, in this regard, seems to be the most suitable option for the establishment of SAE Level 4 highly automated driving functions on urban mixed traffic roads. This allows human intermediation to take control remotely over the critical situations where an AV failed or lack the ability to handle itself. Thus, to do so, there is a need to evaluate and develop such conceptual frameworks that reasoned for a secure and efficient teleoperation because data connection and interaction between the operator and the remote-controlled workplace are also must-have features required for this.

The study offers a defined framework for an advanced interactive system that ought to be sensitive to transition interfaces between automated vehicle handover and takeover requests. The study looked at the implications, possibilities and challenges that may arise in the United Arab Emirates (UAE). The study holds the stance that the successful and effective implementation of HMI and AV in future transportation systems can be practically realised by a careful and rational risk management associated with vehicle and user interface-related technology. The motivation is based on the notion cited in Mathew and Al Mansoori (2018) [9].

Recent studies have advocated the use of varied design frameworks to achieve this. From the perspectives of nature of the interaction, physical traits and users' requirements, Owensby, et al., (2018) [11] suggested an 8-point interface design framework to map interactions between pedestrians and AVs. The introduction of automated vehicles into traffic implies the necessity of advanced interactive policies and strategies for automated vehicle users. In this regard, Bengler, et al., (2020) [4] offered a holistic HMI framework for automated vehicles, encompassing the interactions between both outside and inside the vehicle. Although both hardware and software solutions are tested and available for vehicle teleoperation. However, to the author's knowledge, very less real-time, virtually human-interactive investigations have been expounded to develop and design an HMI for highly automated vehicle teleoperation that follows a human-centric design and usability evaluation process. For instance, survey-based studies conducted by Al Barghuthi and Said (2019) [2], and Nassiri, et al., (2018) [10] are a few to mention.

Notably, there is a research gap regarding HMIs for remote-control of AVs in the public transport context, tailored to the expectations and needs of the operating styles of control stations, specifically in the urban areas of the UAE.

The primary objective of this study is therefore to create an advanced and interactive user interface that allows the teleoperation of highly automated vehicles in a user-centered design process. While the secondary objective it to evaluate the framework with regard to usability features, information parameters, situation responsiveness, user acceptance, attention and capacity. "25% of autonomous vehicles will be launched by 2030 in the UAE" (Mathew & Al Mansoori, 2018, p. 1) [9], besides Expo 2020 and Road and Transport Authority (RTA) are operating towards Intelligent Transport System (ITS) to facilitate this (2018). If these developments are already taking place, soon enough AV vehicles will be able to interact with other vehicles including smart city system, the Internet of Things (IoT) tools, devices and ITS. However, user accpetance and adoption in this regard, works as an imperative for the success of any new technology introduced. Besides, ISO conceptualisation of usability also require it to be effective, efficient and satifactory. It is therefore, from these concerns, the research question arises as to whether the advanced interactive HMI's general perception of implication and acceptanec is suitable, based on the aspects of features, information, situation responsiveness, usability, user acceptance, attention and capacity in the UAE.

2. Methodology and Instruments

To get a holistic picture of research objectives, the methodology adapted consists of several steps that are closely linked to one another. First, through a systematic data analysis based on the existing literature review, tests are executed to study the general and specific perception of the suitability of HMI in the UAE. Then an interactive user interface web-based prototype is developed grounded on ISO's user-centered design process. The intention is to provide a holistic concept of HMI for developing a remote operation workplace. Then the experimental study is conducted with 15 experts in the field. Their responses are gathered and analysed using standard questionnaires and structured interviews. The study has relied on the groundings provided by Kettwich, et al., (2021) [7]. The details are as follows:

2.1 Generic Click-dummy Prototype Approach

As a first step, possible scenarios relevant to teleoperation are defined and analysed. This is done hypothetically, and observations are carried out using video analysis of these critical scenarios while interacting with AVs and other road users. Besides observations, interviews with control station employees followed by brainstorming sessions by experts in the field are also conducted.

Then, as a second step, from the relevant scenarios, user requirements are derived, and a low-fidelity prototype is created to meet the necessary conditions. It is then enhanced and improved until a prototype user interface emerges.

The interface consists of six screen displays. One of the monitors is a backup-screen integrated into the desk. The rest of the five are normal wide-angle display screens, which could be operated with a keyboard and mouse. Following are details of the instruments used in the study:

2.1.1 Video Screens: A Detailed Overview

The first two screens in the top row display video images. For video-streaming, standard screens are chosen. The frontal view is shown across all the screens in regular mode, creating a large area to visualize and perceive objects in the peripheral field and ensuring situational responsiveness through a broad viewing angle. If things go wrong, further camera displays could switch the right and left view display screens with manual selections or automation. The constant video stream enhances virtual telepresence and allows the human operator to stay up-to-date even when multiple incidents are being addressed at the same time. The front view images are always displayed on the central screen. Given the actual scanning phenomenon mentioned above, the central position of the said screen, along with the connected distribution screen, ensures a sustained focus of attention on the most important screens. The following Figure 1 shows the distribution of items across the monitors as a click-dummy menu structure, followed by the details of each elemental feature:

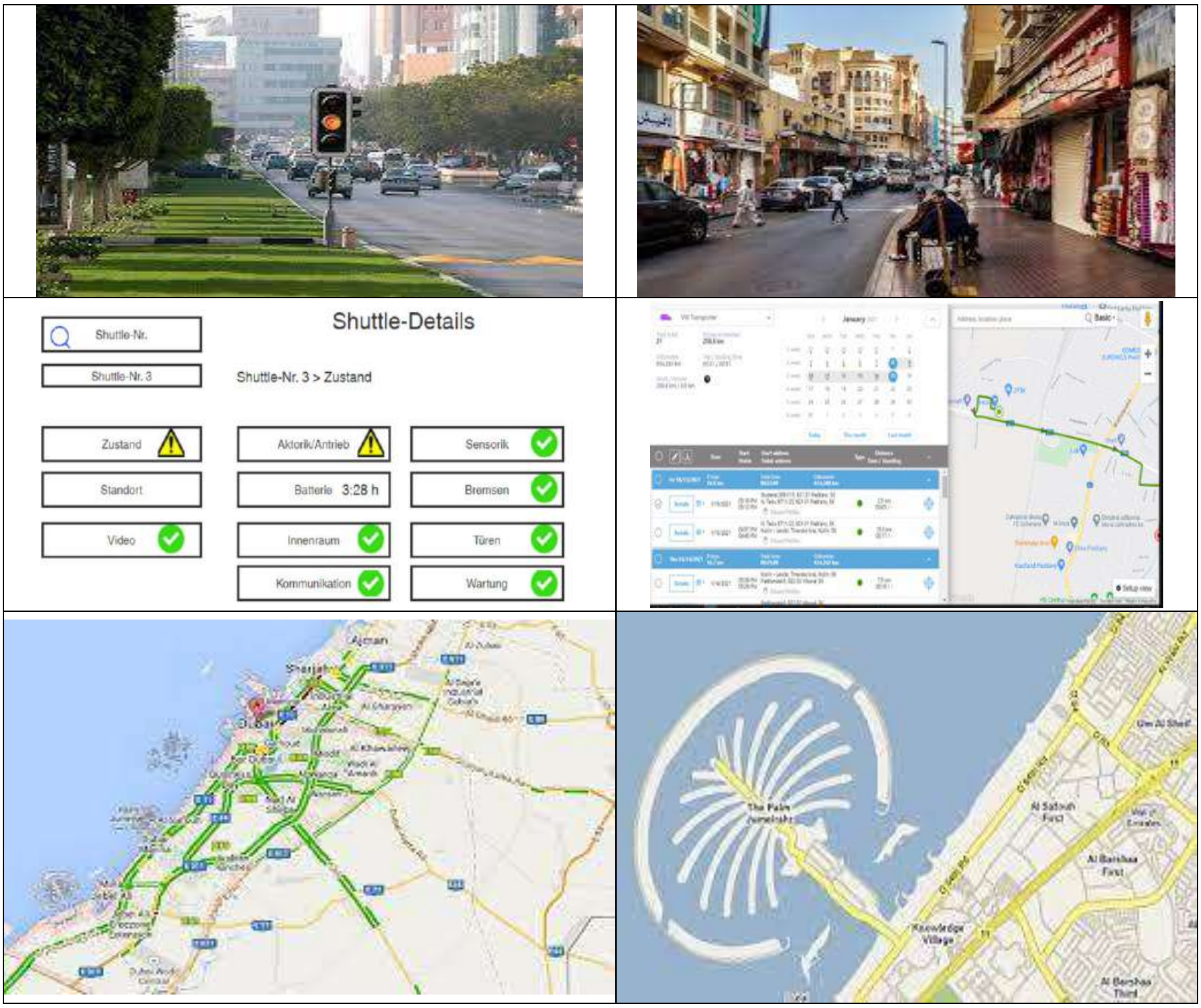

Fig 1: *Video Screens Prototype*

2.1.2 Detailed Screen Overview

Regarding the details of the screen, "Video" displays the available camera positions and perspectives in the top line of the screen. In the subsequent row, the first diplay screen provides a precised information of an individual shuttle or vehicle's current status. The identity of the selected shuttle or vehicle and its location are displayed in the navigation menu. A shuttle/vehicle could be nominated either using a drop-down menu or the search bar. Under this there are click buttons. These buttons are labelled as "City", "Location", and "Display". The coloured symbols utilised signifies the overall status of the sub-system. Normal operations are indicated via green tick. An exclamation mark in yellow colour, symbolises one-off fault. Whereas, to indicate a total failure, a red-coloured X sign is used. The colour coding is selected to enhance the conspicuousness of disturbances following the Wicken's-SEEV model (2015) [14]. The menu "City" open up a list of technical options. The options include "Actuators, Battery and Sensorics". "Location" displays the existing position as a road or street name. Underneath this is a plan of the four hypothetical rest junctions, with the most impending stops and rest-points highlighted. Planned and estimated times of departure are given for each stop.

The following Table 1 shows the division and allocation of elememtal or optional features across the screens. Deliberations on click-dummy menu strcture is followed by the details of each elemental feature:

Table 1: HMI User Interface Elements

Screen	Options Level 1	Options Level 2
Video Screen	Visuals	-
Details Screen	City	Actuators Battery Sensorics
	Location	Road Name or Street Name Plan or Schedule
	Display	Presented Cameras
Disruption Screen	Interaction Bar	Accessible Interactive Partners
	Disruptions Ticker	Incoming Notifications Notifications In Progress
Map screen	Map	-
	Layers	Rest points/Stops Routes/Trajectories Traffic Density
Backup Screen	Map	

2.1.3 Disturbance Screen Overview

Regarding the disturbance display, it consists of a communication bar and a table. The function is to display incoming notifications about the disruptions and the disruptions ticker. The interactive bar has an enabling function through which the remote operator can connect the relevant actors. It further consists of two sub-sections, “Incoming Notifications” and “Notifications in Progress”. The options displayed under “Notifications in Progress” are “Shuttle Id.”, “Notification”, indication about the type of disruption, e.g., technical fault, the Location or Position, Next stop; and the Processor showing the teleoperator who is processing currently and “Action” to check the details of any fault if encountered. The options for Incoming Notifications are alike, but the parameters Edit allow action to be taken. Here, pressing “OK” is the only available option. In order to deliberate more, clicking the Edit action in the first section will bring up a pop-up window with particulars about the incident. Am inventory of possible actions is also displayed. After successful implementation, a window with a checklist of prerequisites appears. Only when all boxes in the drop-down menu have been checked and verified, the journey can be continued by clicking on “Clearance Granted”.

2.1.4 Detailed Overview of Map Screen

The last display in the third row shows the area around a single shuttle or a map of all shuttles can also be seen. The trajectories of the shuttles are indicated by smooth lines appearing on the map. The shuttles appear as small arrows on the map, each displaying the shuttle Id. It also indicate the route of journey. Towards the right edge of display screen is a navigation column, including a search bar and boxes, clicking which allows shuttles external video to be viewed. Additional levels such as stop-over, rest points, trajectories and traffic density can also be selected and viewed.

2.1.5 Backup Screen

The last monitor in the second row is the Backup screen as security mechanism and additional feature. It is used to serve as backup in case of cyber threat, as the backup screen is autonomou in its functionality. It can also be used to set advanced suggested waypoints to predict. To do so, a customisable map showing the area surrounding the shuttle will appear. Zones and locations where new waypoints can be set, are marked with a yellow line, while the zones where no waypoints can be set can be marked with grey lines. The original pathline is represented by a smooth green-coloured line. By clicking a point, the remote operator can set new waypoints. In order to estimate the shuttle’s route, further options are also available. The security mechanisms of the automation cannot be flouted by the virtual operator.

2.1 Hypothetical Scenarios/Situations

From the perspective of suitability and feasibility of the HMI concept that occur during the teleoperation of driverless or self-driving vehicles in urban transport in the specific areas of the UAE, three hypothetical scenarios are designed to investigate the research perception. The scenarios are chosen to represent the monitoring of the autonomous vehicle/shuttle operation, giving clearance, the execution of the remote control via waypoints. The following three scenarios are chosen:

In situation/scenario 1, the remote operator is required to check an undefined tracking situation which is preventing the sensor to respond. The system then alerts the remote operator about the obstruction identified by any of the sensors of the vehicle/shuttle. This causes the shuttle to come to a halt and await clearance from the remote operator. After speculating the video images and ensuring that no object is hindering the way, the remote operator can check a list of prerequisites on “Details screen” and give approval for the shuttle to continue its journey.

In situation/scenario 2, the shuttle is come to a halt. After inspecting the camera images on the “Details Screen” and identifying the reason that one of the passengers has not fasten the seat-belt. The tele operator will connect to the shuttle’s cabin to request that passenger to fasten the seat-belt. Upon following the instructions, the tele operator then check the data entry of prerequisites and give approval for the shuttle to continue its journey.

In situation/scenario 3, a technical malfunction can confine the shuttle actuator’s steering angle to an unidentified and unspecified degree. As a result, the shuttle is unable to track the trajectory calculated. In order to fix the problem, a field engineer is directed to the shuttle. After the malfunction has been fixed and way points have been determined, the remote operator can check the data entry of prerequisites and give approval for the shuttle to continue its journey. In case of adverse situation, passengers are informed about the problem, excused and available shuttle in nearest location is directed to escort them safely to their destinations.

Here, it is important to consider that an anomaly in the smooth operation and handling of the shuttle is crucial to all the hypothetical scenarios. Besides, it requires and obligates the intervention of the virtual operator and cannot be remedied by automation alone.

2.2 Participants’ Details

A total of 15 male employees from the public transport control authority in the UAE were selected. The selection process is further based on technical knowledge and varied lengths of experience in the said field. Their work experience encompasses monitoring public transport operations within urban areas, including management and initiating action in case of unexpected emergency situations, by organising alternate means of transport to resume regular operations. Participation in the study is voluntary, and the participants were allowed to take a halt and leave the study whenever they like. For ethical considerations and legal constraints, names of the participants are kept confidential. The following Table 2 summarises the details of the participants:

Table 2: Participants' Details

No. of Participants	Age Group	More than 4-year Experience	Less than 4-year Experience	Tech Savvy
4	25 to 34		✓	✓
3	35 to 44	✓		✓
5	45 to 54	✓		✓
3	55 to 64	✓		✓
15 Participants in Total, All Male Members				

3. Methodology of Study Design

The study follows a mixed method design research methodology. First, the HMI prototype was setup utilising a website builder (https://www.justinmind.com/, n.d.) to generate click-dummy model. As the UAE readiness is one of the research apparatuses of the current study in terms of how prepared the UAE roads and the public to implement and embrace HMI and AV technology, so the previous data collected through surveys is also considered while grounding and designing the questionnaire and structured questions. The survey in Figure 2 as cited in Al Barghuthi and Said (2019) [2] acts supplementary in this regard.

Following the triangulation method, the data is collected using a mixed method approach of quantitative and qualitative data collection. The qualitative data is analysed by conducting structured interviews with the participants. While, the quantitative data are self-reported data gathered by means of a questionnaire based on Likert scales designed with the use of surveymonkey.com.

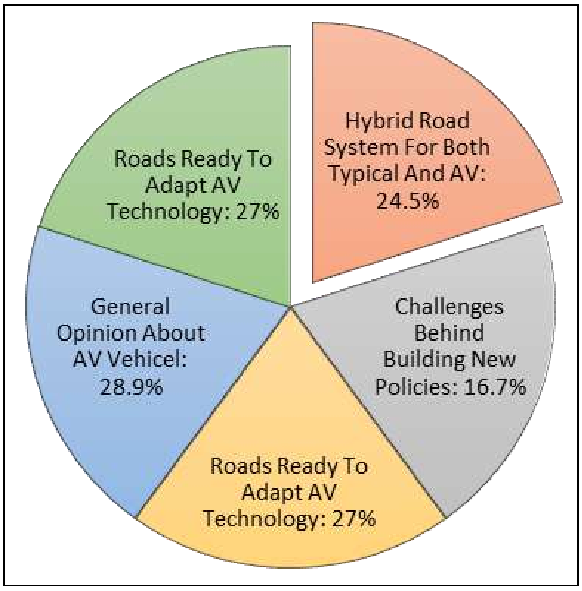

Fig 2: Likeliness to implement AV in the UAE Adapted from Al Barghuthi and Said (2019) [2]

The methodology used is appropriate for the goal of optimising the HMI in the UAE for the following reasons. On one hand, it encourages the evaluator to use standardised questionnaires to make quantifiable assessments of the design. Besides, it offers flexibility for individual suggestions and feedback for optimisations which cannot be quantified directly.

3.1 Structured interviews, Questionnaire and Procedure

The primary objective of the structured interviews is to foster spontaneous elicitation of predominantly popular, unpopular, missing, and superfluous features. It presents both an open and a structured format to monitor limitations related to HMI operations and the dynamics of the information offered. Moreover, it also points out tangible and logical ideas for expansion. While, regarding the quantitative data collection, the informative value of operations of the HMI and the significance of information presented is analysed quantitatively on Likert scales and is evaluated through the statistical analysis.

After the participants are familiarised with the click-dummy, the basic functions are explained in regular operating mode. Participants are then given space to ascertain and become familiar with the web-based prototype system. They were allowed to ask questions in order to know more in case of any technological confusion. Then, selected questions based on the NASA Task Load Index (NASA TLX) proposed by Hart (2006) [6] and the SEEV model (Wickens, 2015) [14] are used. The feasibility of using these models lies in their ability to comprise and cater attention-related prompts and indicators to resolve disturbances, and facilitate information presentation along with future projection.

Similarly, the questionnaire used is directly in accordance with the scenarios and criterion mentioned earlier. Following each scenario, the participants are questioned about the specific disruptions and the suggested measures to resolve them. After the participants completed the questionnaire, a structured interview took place.

4. Analysis and Results

The results are achieved based on the following criterions; it looks at the features of click-dummy prototype, information parameters utilised, situational responsiveness, usability and user acceptance, attention and capacity.

4.1 Features

According to first criteria which looks at the Features of click-dummy protype HMI, the remote operator workstation must offer the required information about the functions to observe and supervise the automation. It must also offer information about the disturbance and allows the remote operator to rectify the fault. Table 2 presents inferential statistics regarding the first criteria. For all scenarios tested, the mean of the subscale "Resolving Disturbances" of the SEEV-related questionnaire which measures the HMI's competence to resolve disturbances (1 = insignificant to 5 = very significant) is considerably greater (all $p<0.05$) as compared to the subscale mean, $M_{crit} = 3.05$ (H1: $\mu > 3.5$, H0: $\mu \leq 3.5$). This indicates that the participants believe the prototype to be effective in terms of aiding to resolve the disruptions. For all features, the means of the usefulness ratings (1 = not convenient at all to 5 = very convenient) are also considerably greater (all $p < 0.01$) as compared to the subscale mean, $M_{crit} = 3.05$ (H_1: $\mu > 3.5$, H_0: $\mu \leq 3.5$). This indicate that the featuristic structures of the prototype are also considered worthy and useful.

Table 3: Descriptive and Inferential Statistics Regarding the Criterion "Features".

SEEV: Resolving Disturbances						
SEEV: Resolving Disturbances						
	M_{emp}	SD_{emp}	95% CI[LL, UL] 1	M_{crit}	V2	**p (est.) 3**
Scenario 1	3.79	1.17	[3.05, 4.52]	3.00	55.00	<0.05
Scenario 2	3.93	1.39	[3.05, 4.78]	3.00	64.00	<0.05
Scenario 3	4.68	0.45	[4.38, 4.96]	3.00	79.00	<0.001
Usefulness Rating of Features						
"Map Screen"						
Selection Of Vehicles/Shuttles	4.85	0.39	[4.58, 5.08]	3.00	77.00	<0.001
Map Adjustment	4.94	0.29	[4.73, 5.11]	3.00	78.00	<0.001
Display of Stops	5.02	0.01	[5.00, 5.01]	3.00	79.00	<0.001
Driving Path Display	4.59	0.91	[4.02, 5.17]	3.00	77.00	<0.01
Traffic Density Display	3.76	0.63	[3.37, 4.15]	3.00	38.00	<0.01
Overall	4.65	0.23	[4.51, 4.79]	3.00	80.50	<0.01
"Disturbances Screen"						
Communication Bar	4.50	1.00	[3.87, 5.15]	3.00	65.50	<0.01
Display Of Incoming Disturbances	4.92	0.29	[4.74, 5.11]	3.00	79.00	<0.001
Display Of Disturbances Currently Processed	4.58	0.67	[4.17, 5.00]	3.00	67.50	<0.01
Pop-Up Window to Overcome Disturbance	4.67	0.50	[4.36, 4.99]	3.00	78.00	<0.001
Pop-Up Window to Check Assumptions	4.17	0.94	[3.58, 4.77]	3.00	36.50	<0.01
Overall	4.61	0.46	[4.31, 4.91]	3.00	77.50	<0.01
"Video Screens"						
Overall	4.75	0.62	[4.35, 5.15]	3.00	67.00	<0.001
"Details Screen"						
Display of City	4.33	1.07	[3.65, 5.02]	3.00	54.50	<0.01
Display of Position	4.25	0.62	[3.86, 4.64]	3.00	67.00	<0.01
Display of Next Stops	3.92	0.52	[3.59, 4.24]	3.00	54.00	<0.01
Display of Estimated Departure Time	4.25	0.46	[3.97, 4.55]	3.00	78.50	<0.001
Display Of Actual Departure Time	4.33	0.49	[4.02, 4.66]	3.00	78.50	<0.001
Cameras Selection	4.50	1.00	[3.86, 5.15]	3.00	65.00	<0.01
Overall	4.30	0.45	[4.01, 4.59]	3.00	79.00	<0.01
"Backup screen"						
Overall	4.58	0.68	[4.16, 5.02]	3.00	66.00	<0.01
Features overall	4.59	0.27	[4.42, 4.74]	3.00	78.50	<0.01

Likewise, the following Figure 3 summarises the features which are specifically mentioned by at least five participants. *Feature Liked* presents which class they are assigned. N shows that how many participants mentioned them. It is then followed by a typical statement given on the respective feature. Classifications with the most mentions are the disturbance displays with 14 mentions, design with 11, camera view with 6, backup screen with 3, shuttle details with 2, and map view with 2 received in all. Regarding other fallen features, it is highlighted by one participant only. Instances include, the modification of the menus, the number of menu taxonomies, the incorporation of error messages and the map views as well as the transfer of error messages.

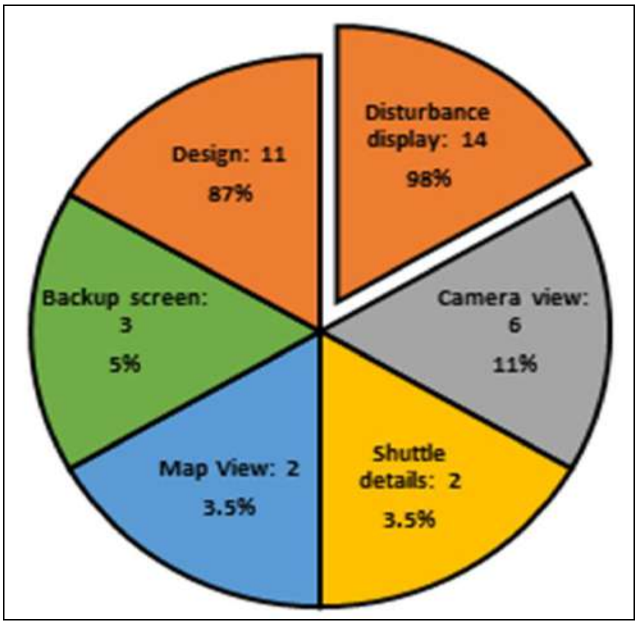

Fig 3: Likeness of Features Recognised

Table 4: Qualitative Summary of Features Recognised

Feature Liked	N	Sample Statements
Overall Design	5	"I like the way information is distributed across multiple screens".
Screens Clarity Division	4	"I like the user interface very much; it is very logically structured and clearly designed".
Relevant Information Display	3	"Unnecessary notifications do not disturb me following the flow of information".
"Disturbances Screen"		
Options to Resolve Disturbance	5	"The process is feasible, logical and very clear".
Communication Link	4	"You can communicate and interact with other people directly".
Presentation of Disturbances	4	"Whenever something is out of place, the details about it are presented with an exclamation mark."
Disturbances Screen	5	"I like how incoming disturbance notifications are displayed on the central screen".
Distribution of Tasks for Processing Disturbances	4	"Beep Prompt on receiving a task establishes who is accountable for what".
"Backup screen"		
Suggested waypoints	5	"Setting waypoints is convenient for getting the shuttle off or on the road".
"Video Screens"		
Video Images	6	"The visuals are supportive and very convenient".

Likewise, the following Table 5 summarises the missing characteristics. At least five participants mentioned them. The components are categorised in terms of display. Their average status rating (1 = not significant at all to 5 = very significant) and the number of participants who mentioned them is analysed and summarised. Missing features, which are stated by the participants are related to the information of the shuttle type, the possibility to direct a replacement vehicle instantly, just one click to admit fault reports, the display of road names, a camera with a 360-degree view of the vehicle interior and the documentation of previous trajectories.

Table 5: Summary of Missed Features

Feature Missed	*N*	*M* Significance	Sample Statements
"Details Display Screen"			
Pertinent Information regarding Disruptions	5	5.55	"It is preferable to concentrate on the essentials and significant things".
Less Screens	3	4.41	"A maximum of five to four monitors is enough".
"Disturbances Display Screen"			
Emphasizing of Disturbances	4	5.50	"Passenger's emergency calls should be prioritized".
Visual Prominence of Incoming Notifications (Using Color-Code)	4	4.69	"Visual highlighting of Incoming notification is preferred and more suitable".
Auditory Prominence of Incoming Notifications	5	5.55	"I would like to hear a beep sound whenever a notification comes in to grab immediate attention".
"Map Display Screen" Clear (Colorful) Display of Trajectory	3	4.69	"Bold and bright warm colors can be used to highlight the trajectory. The lines are thin and not clear enough".
"Video Screens"			
Moving Cameras	4	5.50	"Remote access to regulate the camera's view can be an additional option".
Less Screens	3	4.40	"Two monitors would be enough"
Camera displaying Vehicle Outside View	3	3.51	"To avoid blind spot, having a bird's-eye view outside the camera can be an additional improvement".

Over-all, the participant's score shows that the features are rated highly relevant.

4.2 Information Considerations

The criterion 2, which relates to information considerations, states that in order to monitor the automation, the remote-control workstation must provide the crucial data. It must also provide the crucial information related to the fault identified. Troubleshooting assistance in this regard would be supplementary. Overall, the participants rated the prototype's information parameters as very significant (M = 5.90, SD = 1.01, 1 = not significant at all to 5 = very significant). The maximum mean scores are for the presentation of important information on the detail screen (M = 5.58, SD = 0.53), followed by backup display (M = 5.57, SD = 0.91), and map display (M = 4.49, SD = 0.76). The following Figure 4 summarizes the inferential statistics on information parameters.

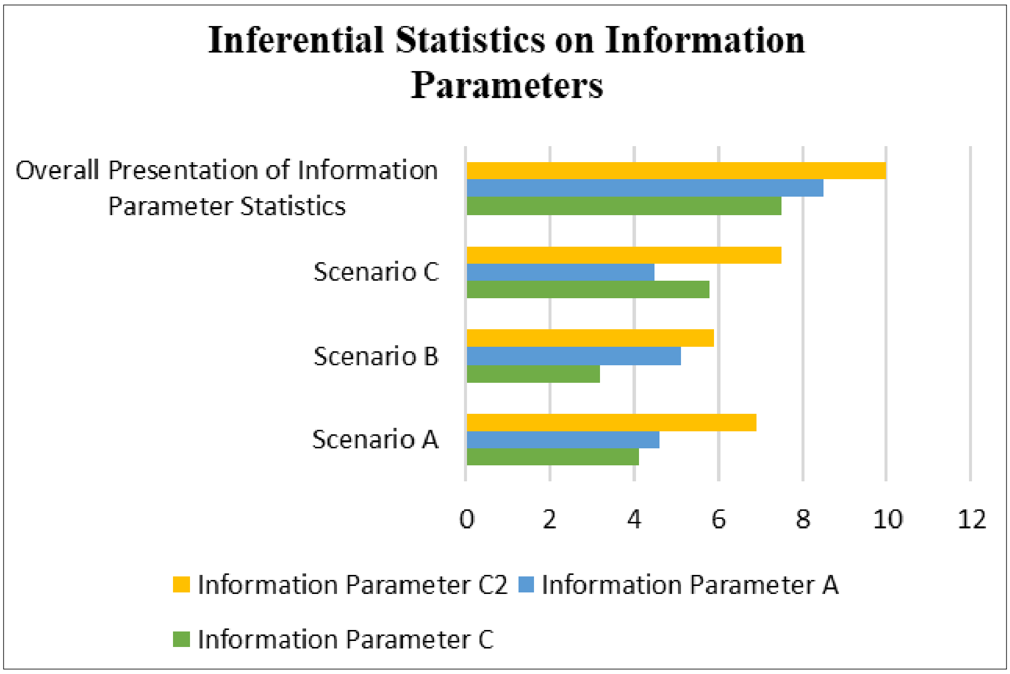

Fig 4: Information Parameters Inferential Statistics

It can be seen that the overall results regarding the information parameters of the prototype criterion are somewhat similar to those which were identified in previous criterion. However, some participants missed the information about vehicle/shuttle occupancy and its exact location.

4.3 Situation Responsiveness

According to criterion 3 which is about situation responsiveness, the remote operator workstation must provide the remote operator with a high level of situational responsiveness. The following Table 6 shows the statistics of actions associated to situational responsiveness. The overall SEEV-related items' subscale Projection of Future (1 = poor projection of future failure to 5 = high projection of future failure), the empirical means are considerably larger ($p < 0.05$) than the scale mean of 3.5 for Scenarios A and C (H1: $\mu > 3.5$, H0: $\mu \leq 3.5$), with an insignificant difference for Scenario 2 ($p > 0.05$). The table shows that a moderate level of situational responsiveness is achieved. This is quite relevant in terms of multifaceted optimization and implementation of the prototype at further advanced level. The differences in scenarios support the presence of situational responsiveness in terms of HMI prototype interface.

Table 6: Situational Responsiveness Inferential Statistics

Construct	*Memp*	*SDemp*	95% CI1	*Mcrit*	*V2*	*p* (est.) 3
Projection of Future (SEEV)						
Scenario 1	3.90	1.05	[3.23, 4.55]	3.05	59.00	<0.07
Scenario 2	3.22	1.28	[2.42, 4.00]	3.00	34.50	<0.29
Scenario 3	4.19	0.61	[3.81, 4.55]	3.05	79.00	<0.03

4.4 Usability and User Acceptance

According to this criterion which is about usability and user acceptance, the attention of the user must be direct to information which is presently relevant in the remote operation user interface. Table 7 summarizes that all SEEV scores' means (1 = low consideration to 5 = high consideration) are significantly larger than the scale means 3.5, for all scenarios investigated (H1: $\mu > 3.5$, H0: $\mu \leq 3.5$). It is significant to notice that somewhat similar results are shown in the subscale representation of information which is conceptually associated with attention. The subscale mean scores are considerably greater as compared to the scale means for every scenario. The quality and usefulness of system, information and interface are rated well above the mean of scale.

Table 7: Usability and User Acceptance Statistics

Construct	*Memp*	*SDemp*	95% CI1	*Mcrit*	*V2*	*p* (est.) 3
PSSUQ Overall	5.52	1.18	[4.78, 6.27]	5.00	64.00	<0.01
Usefulness of System	5.75	1.15	[5.03, 6.47]	5.00	67.50	<0.02
Quality of Information	5.41	1.11	[4.71, 6.12]	5.00	74.50	<0.02
Quality of Interface	5.26	1.72	[4.18, 6.34]	5.00	58.50	<0.4

Similarly, percentile in Figure 5 shows user acceptance of the remote workstation shows difference on the Likert scale scores (1 = not recommended to 5 = highly recommended) in pre-test and post-test statistics.

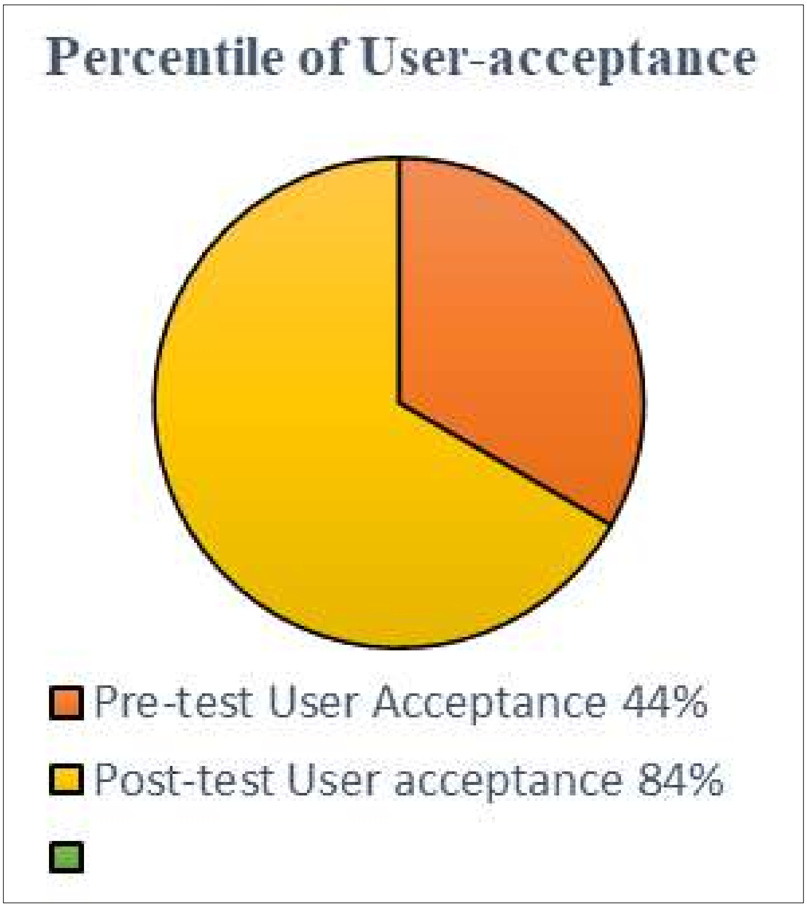

Fig 5: User Acceptance, Pre-test & Post-test Statistics

4.5 Attention and Capacity

According to criterion of attention, the attention of the user must be directed to the pertinent information which is presently appropriate in the remote computer terminal. The following graph summarizes the user's response to the information which is conceptually linked to the attention decoded from scenario 1, B and C mentioned earlier.

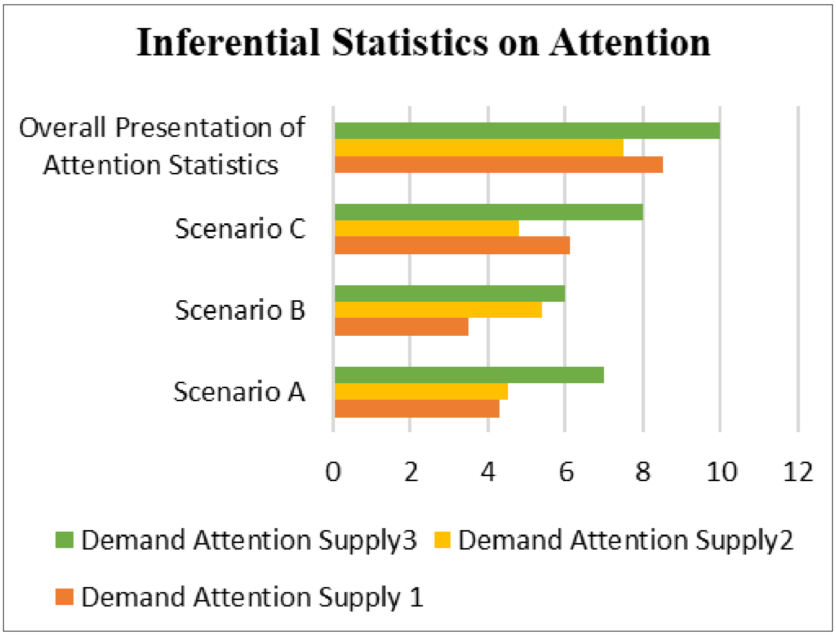

Fig 6: Inferential Statistics on Attention

Similarly, as per criterion about capacity, the mental and physical capacities of the user must not be overwhelmed on remote operation workstation. As shown in the Figure 7, for all scenarios, the percentile scores for the overall NASA-TLX questionnaire (1 = low workload to 21 = extreme workload) are considerably lower ($p < 0.02$) as compared to the scale mean, 12 (H1: $\mu < 12$, H0: $\mu \geq 12$), indicating a lower workload. The details are summarized below:

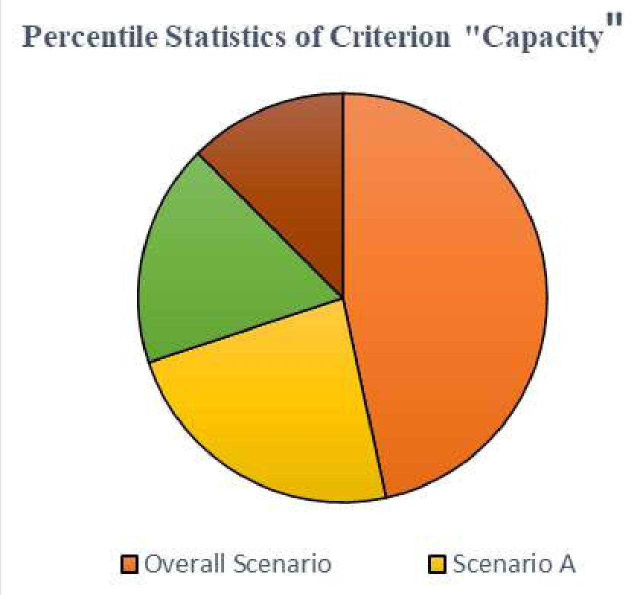

Fig 7: Descriptive and Inferential Statistics on Capacity

As an additional exploratory section, at the end of the structured interview, the participants could also make suggestions for further improvement.

5. Current Trends

In this study the researcher has proposed click-dummy HMI concept which is evaluated based on three hypotheticals yet relevant scenarios which can serve as a framework for categorizing and actualising the existing HMI perceptions. Although, the existing HMI concept is capable of handling a variety of scenarios beyond those tested. However, due to a great variety of methodological approaches and methodological limitations, it should also be borne in mind that there are situations that the control station can only handle to a limited extent, e.g., dirt can block sensors or cameras, any injury can be faced by the passenger, receiver board GPS on shuttle can get out of order or other software and hardware issues can be faced.

On the other hand, it is possible to upscale the HMI to other types of vehicles as well as a context of use, like ambulances. Additional features and interfaces to plan, outlook, and payment dispositions can also be feasible in this regard. The UAE is determined to adapt the technological changes. The progression of the major cities and huge groundwork plans like implementation of the Driverless Shuttles by the Roads and Transportation Authority (RTA) of the UAE, Flying Cars, Masdar city Personal Rapid Transit System, and Automated busses prove that the country is capable and the results of which will be materialised in the next decades. Mobile bodies, other than shuttles or vehicles, like delivery bots are also likely to be implemented soon. Similarly, Wiemer in DLR series of research project highlighted that an AV driving module might be exercised to carry goods, transport people and manage supplies.

Although the limitations in ongoing considerations include trust with technology, security and safety measures, ethical dilemmas, responsibility measures and having a sustainable environment. A fully automated HMI concept could only become a practical reality once the considerations above are answered.

6. Conclusion

Following the conceptual framework of user-centered design feasibility features, the study presented an immature concept of HMI assessed by a highly selective participants and its probable perspective users. There is not a wealth of practical HMI concepts for teleoperation, at least not in the context of urban transport, particularly in the context of the UAE, except a few instances mentioned earlier. To the author's knowledge, the click-dummy prototype framework presented in this study is unique as it is customised to the context of urban transport control centres in the UAE. Hence, findings of this evaluative endeavour advocates a user interface and propose a conceptual framework which can be utilised for further optimization.

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