Situation Aware Content Driven Multimedia Service Fusion in Avionic Informatics
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Abstract: - The objective of the work is to propose a situation-aware multimedia composition services based on different forms of information content when collaborated media services are demanded in an avionic information system. The timely composition and managed quality of information is needed and to be rendered to meet the pilot’s emergency requirements at that instant of time. Most of these multimedia applications are to be choreographed as virtual services as per the situation and the pilot’s requirements that can be composed statically or dynamically. The content and the context play an important role in determining the overall quality of such applications once they are played through the respective players or viewer software components which may be deployed as services. The on demand rendering model addresses the interaction of the pilot with the mediator framework through standard interfacing techniques focusing quantitative and computational techniques on the selection of correct service, its verification and filtration towards situation aware decision making during the media service composition and rendering phase.

Keywords: - Content based collaboration, Situation aware services, Dynamic composeability, Media services, Correct sequence, Service fusion ontology.

1 Introduction
Modern day avionics require multimedia applications and resources not only to entertain passengers but also help the pilot to control the flight during critical environment conditions. The rugged airborne systems product family includes critical system components to enable in-flight broadband services including: email, multimedia capabilities, video-on-demand, games and additional entertainment choices in a fully-integrated wireless cabin over a broadband air-to-ground or air-to-satellite link to provide secure wireless connectivity for commercial airlines and general aviation. The service collaboration through the respective contents is achieved when it is demanded to render a reliable, reusable and sustainable services apart from other quality of service parameters like security and privacy. The correct values of the needed content in the expected context at the right time as per the requests can be achieved through the proposed content driven on demand multimedia services. The decision making process includes three stages, where the first stage involves a binary decision that controls the dispatch of modality transform and data transcoding; the second involves a careful examination of various parameters to find out the best trade-off between information abstraction and download time; the final step involves data prioritization. The data integration plays an important role in achieving this collaboration that is based on the contents and their associations to arrive at the expected quality. The pilot is a major risk element in decision making, when evaluating flying risks, a developing potential hazard must first be detected and then analyzed and finally resolved. As an aid to risk assessment, five risk elements are reviewed: pilot, aircraft, environment, operation and situation. The pilot has the capability and the responsibility for determining the associated parameters with a particular flight [1]. Software development for the complete dashboard instrument cluster comprising driver, application and display modules, and hence, the need for design, development of multimedia system for a distributed flight navigation is essential [2]. The media services are essential not only for flight management and
control systems but also for cockpit and multimedia information systems. Many ongoing design efforts are aimed at enhancing situation awareness in the cockpit by taking advantage of new technologies such as advanced avionics and sensors, data linking, global positioning systems (GPS), 3D visual and auditory displays, voice controls, experts systems, helmet mounted displays, virtual reality, sensor fusion, automation and expert systems [3]. The key problems of aging avionics is to determine the systems that are the high costs drivers in order to select those that should receive priorities and determine the requirements for the replacements [4]. JDL(joint director of laboratories) model takes from input different sources like sensors, databases, humans and simulations and performs the fusion from starting level to end level and finally gives the output to the user through the physical interface. According to Luo, Yih and Su, multi-sensor information fusion refers to the process of combining sensory data from multiple sensors to provide the more reliable and accurate information in different levels [5]. The style of defensive Aids systems that comprises of a suite of sensors, effectors, algorithms and human machines interface which seeks to provide situational awareness, timely warning of threats [6]. The problem which any pilot can identify with is that the least efficient data transfer medium is through the ears. Hence the avionics informatics field is going to be faced with number of service providers, system types and data transfer protocols. TIS-B is a d\fusion of ground based information, and other mode S equipped aircraft, in to a single threat presentation [7]. Effective management of air traffic in congested airspace during episodes of convective weather requires decision support tools that translate weather forecasts into air traffic impacts and then use those ATC impact forecasts to suggest air traffic management strategies. Combining the data from multiple sensors reduces the number of false alarms a pilot sees during a mission and helps to determine where the target or threats are sooner, allowing the pilot to take the necessary steps faster. Open FMV standards conformance and sensor front end avionics technology architecting approaches drive the level of Video-NIIRS ranking possible in an airborne cockpit display system. Integrating commercial broadcast, Internet multimedia and cinema high definition (HD) video COTS technology to deliver progressively higher Video-NIIRS ranking becomes a systems-of-systems architecting challenge across the military airborne avionics enterprise. The major multimedia contents are of the forms like text, image, audio and video and the expected content parameters are varying with respect to the viewer satisfaction and the available source quality or raw content quality (RCQ). A formal definition of multimodal mood-based annotation is given and the architecture is illustrated, considering both the interaction process between the user and the system and the audio interface of the architecture. A concrete application of the architecture in an annotative locative media project is also presented [8]. Essentially, it is argued that automation and information systems should focus, incorporate, and assist the humans, and that the use the wisdom of simplicity in order to control complexity should prevail against the attempt to develop complex systems that usually are a consequence of unnecessary requirements. There are three measures of the association: support, confidence and interest. There are different types of associations: association between image content and non-image content features and the concept of content-based multimedia association rules using feature localization.[9]Information Richness theory suggests that only the right amount of information could reach the goal of optimal dissemination. Under the situation of high task uncertainty, the increasing amount of information becomes ineffective. The administrator in an organization needs to identify the problems, instead of presenting more information.

The organization of the paper is as follows: Section 2 brings the issues in the content interpretation and communication overhead due to large number of unwanted information and noise in a situation aware cockpit decision. The next sub section 2.1 brings the existing standards in disseminating multiple data from avionic instruments and sensors as multimedia service including digital video and audio. Section 3 proposes ontology for the heterogeneous information towards a decision algorithm based on the critical situation. Section 4 proposes a formal model for selecting the correct sequence of media service as a middleware component and the sub section 4.1 displays the sample output when such a situation is simulated with all pieces of information fused as per the request from the pilot with their controls using Max MSP software tool. Section 5 concludes the work with the limitation of the proposed situation aware media renderer with its timing complexity and emotional behavior dependence in the future work.
2 Aero Information Content Dissemination Standards

The improper and untimed composition of various information content is due to low-Visibility Conditions, the Airport Surface Environment, Communication and Route Change. Recent technological advancements in sensor, navigation, database and computer graphic technologies have made the introduction of electronic taxi map, which displays an inevitable addition to the aircraft cockpit. The information contents are Cockpit sights, sounds, and smells are extremely important to building a pilot's SA and emergency awareness. These are the parameters which indicate the health of the aeroplane. Pilots have to navigate a series of obscure menu pushbuttons to access different aeroplane functions.

The Information Dissemination Standards in Avionic Informatics is categorized into certain standards such as open FMV, Firewire etc. which are required to maintain a conformance to the requirements during critical situations in the final cockpit display. Open FMV standards conformance and sensor front end avionics technology architecting approaches drive the level of Video-NIIRS ranking possible in an airborne cockpit display system. Identifying how much video signal distortion and visual content filtering is occurring between the originating HD FMV sensor output throughout the avionics platform architecture to the final cockpit display assists the avionics systems integrator in determining what architecture changes are necessary to attain higher Video-NIIRS scores[11].The IEEE 1394 Firewire standard Isochronous transfers use reserved bandwidth to guarantee that time critical data such as audio, video and real time control messages arrive within a controlled window. This is indeed the reason for the immense popularity of this new standard in multimedia, digital video and growing penetration into real time industrial control applications, especially automotive and aerospace. Where pilots will see the most improvements in situational awareness is with ADS-B In, which refers to the reception by aircraft of ADS-B data. ADS-B In is in contrast with ADS-B Out, which is the broadcast by aircraft of ADS-B data. ADS-B In will enable flight crews to view the airspace around them in real-time[10]. The ESP elevates the situational awareness of the user by providing support for multiple tactical standards and protocols presented together in a common operating picture. Examples of the supported capabilities include Variable Message Format (VMF), Link-16, publish and subscribe, text-based instant messaging (or chat), system status webpage, and video streaming or playback.

3 Avionics Media Service Ontology for Situation Aware Decision

The media services with their instances and properties are specified in ontology to identify the correct needed service. Each desired instance or property in the request is matched with a corresponding component in the service ontology as per the avionic information standards [12]. The different types of relations exist between the entities in a fusion scenario. Some of the functions are executed in hardware and others are executed either in the cockpit system or in the proposed middleware component. The fusion model differs from the other integrated models in the way to consider and compose the needed information as per the request of the pilot based on the situation.

Fig.1. The Service Fusion Ontology for Decision Making

The Figure 1 explains the process of taking situational aware decisions, which includes a set of algorithms which supports the decision. There are situations like jamming, icing, navigation failure etc, which can be dealt by performing certain procedures. First the information is filtered, and then a processing is done on the filtered information. The need for correctness is the significant section which decides the decision process, which can be verified using certain verificational parameters.
4 Calculus of Correct Media Service Sequence

As the proposed Service Assistance Socket (SAS) is enabled in the avionic media, the service render object verifies the authenticity and authority of the requesting object based on the device address. The operational availability of the requested services is measured in terms of the instant availability of all the constituent services. The set of requests are received and organized based on the time of reception and sorted according to the severity and criticality of the situation. The automated multimedia renderer service (MRS) may follow an automation encompassing the emergency situation, required to monitor the responses through the help of virtual services from the respective devices, say

\[ \text{SAS: } = \text{MRS= \{ SC, V, G, (S, D, I), P, R \}} \]

Where SC represents the set of situation contexts, V represents the set of Virtual service connected through an On-board gateway indicated by G. The media services are represented by a multi set of situations indicated by S, Device as Services by D (DaS) and the Information as Sought (IaS) including network services represented by I. The other control elements like playing the call back to know the severity and location identification of the incident indicated by P with a Recording service R with the playback facility. The decision and correct deployment of essential media services can be found using a technique using the calculus of service sequences based on the context aware and intelligent decision making approaches. The correct service sequences are constructed using the technique called “CALculus of MEdia Service Sequence (CALME)”.

The device request service can be considered as the required last minute information or calls from air traffic control stations, co-pilot instructions, engine parameters, crew-board dialogues, environment warnings and air-passenger movements. It can be considered as a finite set or \( R = \{ R1, R2 \text{ and } R3 \} \). These are appearing and flooding media server inlet through various ports with infinite possible combinations of their sequences based on the severity and frequency of incidents. The Rendered Service Sequence is the set of services based on the legitimacy and need of the incoming requests. The devices may send their information as a sequence with criticality or severity factor \( \rho \), can be represented in different devices like altimeter, speed indicator, pressure indicator, distance from nearby air control authority, radar, gyroscope and campus through the respective devices in their formats. These crucial information are coming through wire, wireless, mobile, camera and sensor network, say \( N = \{ \text{GPS, DVI, Sensor, Radio} \} \) mentioning the finite contexts of the situation like \( SC = \{ \text{AUDIO INTERFERENCE, ICING, ENGINE FAILURE, JAMMING, NAVIGATION FAILURE} \} \) like there may be many situation contexts represented \( SC1, SC2 \text{ and } SC3 \).

The Media Service S1, S2 and S3 can be exercised with different components as its size varies from \( t1, t2 \text{ and } t3 \). A generic input media requests may be represented with “present” or “past” terms as shown below:

\[ \text{MS}': = \text{ present service request : delay. Context (content)-----[2]} \]

// Media service request is initiated by its content and declaring the context in which the request is made//.

\[ \text{MS}''': = \text{ past service request : severity . Context (content) } \]

//the service request is replicated with the same or different content but in the same context//

\[ \text{MS}''': = \text{ request (need). Context (content) } \]

//the request is parameterized with its time and severity //

For example, the request which needs or demands the engine and the environmental parameters for icing and jamming situations in worst weather conditions can be represented as

\[ MR1:: = \text{ present media service request (engine, environment, I2.45) NAVIGATION FAILURE} \]

If the requests are through wired and global position system services, then the fields like the present or past, request parameters, device parameters and the context in which the requests are generated are collected through voice recognition and passed into the corresponding information processing modules with authenticity. If the calls were originated from unacceptable device addresses and media renderer gateway addresses and service provider ids, then these calls are rejected. All the requests are checked for its authenticity and transformed into another set of guarded service requests G. The “?” symbol indicates that the terms following are the input functions through the in-built navigation system standards or from the broadcasted voice command from the control tower.

\[ MG1:: = \text{ in-built } ? \text{ MEDIA. Service request (engine, mild, 13.22). ICING} \]

\[ MG2:: = \text{ GPS } ? \text{ Media .Service request (altimeter, environment, 14.17). WEATHER} \]
The corresponding automated decision supports the output: MRS is to be based on the calculus of identifying the available response services, their sequences, and their respective values and to check against any malfunctioning of the wired device or wireless network recovery actions like displaying irrelevant data or information from unidentified sources. But if the severity is more and criticality of the detected event is more, then the action may be considered as a past request and permitting to receive more information from the suspected regions. It is also the responsibility of the MRS to find out the possible parallel operations to be taken for the same critical events but to perform two different relief measures like manual decision and assistance from the military if needed together. The MRS services are to be sequenced based on their availability and legitimacy. A media service may be subsumed or contained in other service, for example in the case of an icing situation; a recovery service with safe alert or alarm can be initiated that subsumes the medical service with sufficient amount of oxygen supply through masks with instruction services since both the needed services are for the safety and security purposes of the passengers and crew members. The services can be activated as parallel with number of other services where both the services are essential and requested by the passengers. This can be represented by Parallel Media Service Composition (PMS): S2 || S3. The duplication of similar services to the same requests may not be permitted and at the same time, the duplication is to be permitted for the similar incident in a different location. Since the service requests are stochastic in nature, the MRS systems towards natural incidents are stochastic phenomenon because their functionalities are determined by random natural events happening outside like situations in STORM, NAVIGATION FAILURE and CONNECTION LOSS. The indirect associations of natural calamities with the support services can be thought of as stochastic processes. The possible Bounded Response Sequence has to be determined by the Media Service Scheduler to meet the crisis situation satisfiably. If no media service is needed, it can be represented as C and if different types of services are needed for the same request, then it is possible to sum up the available services and render to the MRS as shown in equation [3]:

\[ \Sigma = MS1 + MS2 + MS3 + MS5 \]  

Parallel services that can be deployed at different locations at the same duration can be represented as shown:

\[ MG = MG1 \parallel MG2 \parallel MG3 \]

The Pilot Request Service Sequence (PRSS):

\[ S1, S2, S3, S5 \]

S1 = \{type of request, severity, parameters, value\}. When more than one service is requested, the Fused Response Service Sequence (FRSS) can be composed as,

\[ S1 \cup S2 \cup S3 \cup S4. \]

The guarded service sequences may have different priorities assigned and accordingly the time factor is incorporated to get another set of services called Deployed Service Sequence (DSS). These services may be represented as,

\[ DS = GPS? Request (weather, high resolution, 800 x 1600, 03.34). \]

Destination-airport Gateway .Service Provider .Device address ! Response. render (runwaymap,800 x 1600).-----[4]

The equation [4] represents the output of a rendered response for a very mild incident that needs weather condition of the destination airport towards safe landing of the aircraft where the arrival airport weather is unknown presently. But the previous records of the same weather conditions are available with which the MRS cannot take correct and safe decision for landing. With higher priority where the
damage is very severe in terms of human lives and properties, the decision support media services should be deployed immediately to prevent further losses. In such scenario, the equation [5] explains:

$$DS ::= \text{GPS} \rightarrow \text{Request} (\text{weather, high resolution, 800 x 1600, 03.34})$$

Destination, airport, runway.
Media, Gateway
Service Provider
GPS Device address ! Response (weather, 03.34).

Once the severity and timely responses are fixed, then the MR services are initiated through national relief centers based on the number of requests.

$$D1 ::= \text{RADIO} \rightarrow \text{response (crew, 03.34)} \cdot \text{ENGINE FAILURE} \parallel \text{DVI} \rightarrow \text{response (passengers, 03.35.200) } \text{HELP} \parallel \text{ATC} \rightarrow \text{response (alert, location (latitude, longitude))}. \text{HIJACK}$$

### 4.1 Service Fusion Results

The textual representation of the sensor data that are needed in determining the critical situation for which the pilot has to react are shown in Figure 3. There are streams such as ATC, ENGINE and CREW BOARD which consists of parameters for the proper functioning. These streams are fused into a single service and given to the main display for the decision making. Audio section, where an audio from an ATC or Co-pilot can be heard with a recording facility to record the current scenario taking place hand in hand as shown in Figure 4. The pictorial visual service is performed using max msp software using certain parameters to pictorize the current situation and the solution for it. For example parameters like Brightness, Resolution, Scaling, etc which are fused together known as Image Parameter Fusion(IPF) and some Image Processing techniques like Segmentation, Feature extraction and edge deduction are carried out before its given to the Media Render Service(MRS) and are finally projected to the pilot as shown in Figure 5. A video interface is created using MAX MSP by integrating several Max objects such as metro and playbar which are used to simulate video parameter fusion as and when needed by the pilot and projected to the MRS. several parameters such as rate, volume, and loop are used for better interpretation and convenience as shown in Figure 6.

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Table 1 is a pictorial representation of data which were used in the Max MSP software for generating an audio, video, image and text design from one format to another. The designed product was verified using LUA, integrated with Max MSP which displays the design in terms of codes.
5 Conclusions

The situation aware content driven multimedia service fusion model is proposed to assist the pilot in taking decision during critical conditions. The media renderer service component with the standard interfaces can be deployed as a middleware component. The correct sequence of media services can be determined by the given technique to the cockpit display system after filtering irrelevant signals as per the ontology. The model has been simulated adhering to the existing media dissemination standards with different information and are fused as per the request of the cockpit crew members. The parameters of the media components can be adjusted to suit the need of the crew member like volume adjustments and replay routines. The data fusion model is experimented with the help of Max MSP and its compatible Lua scripts and the results are tabulated with sample screen shots. The format changes and structural changes of the available data are considered in the work. The limitations of the above model are the non-incorporation of the emotional activities of the crew members and the entertainment services within the flight. The scalability and reliability issues will be considered in the future work to deploy a safe and secure data fusion needed to assist the pilot in needy situations.

References:

[7] Gary Picou, Next generation Avionics Dealing With Data, pp.1..