BIOSTORIES
Dynamic Multimedia Interfaces based on Automatic Real-time User Emotion Assessment

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Keywords: Emotion Assessment, Biometric Channels, Dynamic Interfaces, Multimedia Content.

Abstract: BioStories is the outcome of a three and a half years research project focused in uniting affective and ubiquitous computing with context aware multimedia content generation and distribution. Its initial premise was based in the possibility of performing real-time automatic emotion assessment trough online biometric channels monitoring and use this information to design on-the-fly dynamic multimedia storylines emotionally adapted, so that end users would unconsciously be choosing the story flow. The emotion assessment process was based on dynamic fusion of biometric channels such as EEG, GSR, respiration rate and volume, skin temperature and heart rate on top of Russell's circumplex model of affect. BioStories' broad scope also allowed for some spin-off projects namely mouse control through EMG that resulted in a patented technology for alternative/inclusive interfaces. Exhaustive experiments showed 87% of success rate for emotion assessment in a dynamic tridimensional virtual environment with an immersiveness score of 4.2 out of 5. The success of the proposed approach allows the vision of its appliance in several domains such as virtual entertainment, videogames and cinema as well as direct marketing, digital TV and domotic appliances.

1 INTRODUCTION

In recent years, there have been numerous and serious academic and industrial efforts and investment in introducing innovation to traditional user interfaces and more generally in the field of human computer interaction. These approaches resulted, ultimately, in cross-generation consumer products like the Nintendo WiiMote and Apple iPod and iPhone or exclusive luxury goods such as Microsoft Milan Table or the Diamond Touch from the Mitsubishi Electric Research Laboratories. Despite the distinct commercial success, the fact is that new interaction paradigms are arising and imposing themselves in everyday life.

Simultaneously, there is also a growing investment and attention being paid to both affective and ubiquitous computing. The continuous hardware miniaturization linked with more disseminated, powerful and cheaper wireless communication facilities constituted the cornerstone for context-aware computing possibilities. As traditional multimedia distribution, such as television, has been suffering from extreme content standardization and low levels of significant user interaction, it is believed to exist an important breakthrough opportunity in uniting real-time emotion assessment based on biometric information and dynamic multimedia storylines so that interaction and decisions can be performed at a subconscious level, thus providing greater immersiveness through combining affective and ubiquitous computing towards new interaction paradigms.

It has been in this context that BioStories have arisen as a prototype proposition for generating and distributing highly dynamic multimedia content not confined but with special focus in immersive tridimensional environments in which storylines are based and determined on user's online emotional states that are assessed in real-time by means of minimal invasive biometric channel monitoring and fusion.

As the set of biometric sources is also intended to be as flexible as possible, so that the system can be used in diverse contexts, it encloses the resource of distinct sources namely: electroencephalography, galvanic skin response, respiration rate and volume, skin temperature and heart rate. In order to cope

Vinhas V., Oliveira E. and Reis L. (2010).
BIOSTORIES - Dynamic Multimedia Interfaces based on Automatic Real-time User Emotion Assessment.
In *Proceedings of the 12th International Conference on Enterprise Information Systems - Human-Computer Interaction*, pages 21-29
DOI: 10.5220/0002866700210029

with the need to perform continuous and smooth emotional assessment, the representation underneath the classification is a variation of the bidimensional Russell's circumplex model of affect.

Due to the broad spectrum of the global project, there were several spin-off opportunities from which the mouse control through electromyography is elected for further depiction as an alternative, inclusive and complementary user interface proposition. Considering the BioStories main track, its latest version achieved a success rate of eighty-seven percent regarding emotion assessment with elevated content immersive levels, allowing the forecast of the technology appliance to several domains such as traditional interfaces extension, domotic environments, virtual entertainment and cinema industry as well as digital television, direct marketing and psychiatric procedures

This document is structured as follows: in the next section a global state of the art study is depicted considering emotion assessment, dynamic multimedia contents, hardware solutions and global integrating projects; in section three the broad BioStories work is described in detail by depicting its global architecture, referring spin-off projects and defining the emotion assessment process as well as the multimedia content generation in a tridimensional highly immersive environment. In the following section, the experimental results are presented both for the mouse control through EMG and the main BioStories project; finally the last section is devoted to critical analysis, conclusion extraction and future work areas identification by means of application domains recognition.

2 RELATED PROJECTS

Ekman's emotion model (Wang, 2004) contemplated six main universal classes of affect but in a discrete fashion: anger, joy, fear, surprise, disgust and sadness. However Russell's proposal of a circumplex model based on a bidimensional arousal/valence plane allows for a continuous, analog emotional state mapping (Russell, 1980). The introduction of a third dimension – *dominance* – also proposed by Russell, is still discussed, although generally accepted it lacks of biometric evidence for automatic emotion assessment ends (Russell, 1977).

The resource to biosignals to perform automatic emotional assessment has been conducted with success using different channels, induction and classification approaches. These emotion induction proposals range from image presentation, stage actor representation, personal stories recall or film and multimedia projection (Kim, 2008), (Picard, 2001), (Vinhas, 2009).

Concerning the set of biometric channels elected, there is also a wide variety of incented research work lines, but although some studies focus their attention in multichannel EEG and fMRI with promising results, these approaches are still believed to be either extremely intrusive and/or not convenient in real situations (Fairclough, 2009). Most recent approaches are based in distinct conjunctions of simple hardware solutions for monitoring several biometric channels, namely GSR, skin temperature, respiration parameters, heart rate and blood pressure (van der Broek, 2009), (Kim, 2008), (Vinhas, 2008), each one with distinct emotion classification methodologies but there is a great acceptance and unanimity around the continuous model of affect as well as the resource to biosignals.

Although the common denominator of almost all research project in this field consists in automatic emotional assessment, for the main principle of the proposed work, a special attention must be paid both to online real-time classification and its integration with external systems, particularly regarding human-computer interfaces. There have been conducted several efforts towards human emotion disclosure exploring social networks and chat systems. Despite the theoretical success of these proposals they have faced some usability resistance when used in direct human-human communication (Wang, 2004). However, this limitation is suppressed when emotion assessment integration is performed in pure human-machine interfaces such as the efforts in order to generate audio (Chung, 2006) and images (Benovoy, 2008) emotionally contextualized exemplify.

This integration research track has continuously been pushed further in order to mix affective with ubiquitous computing towards new interaction paradigms that are emotionally context-aware, thus enabling extreme interface dynamism to cope with distinct user moods and emotional responses. These proposals have envisioned and developed systems to integrate real-time emotion assessment based on biosignals processing into diverse domains such as everyday computer interfaces (van der Broek, 2009), or professional car driver environment optimization (Katsis, 2008). This broad scope allows for a plausible perspective of the appliance of such systems in several and distinct human computer interaction domains.

It is in this vibrant and alive research context (Vinhas, 2009) that the current proposition stands, intending to be a valid contribution towards increasingly dynamic and emotionally aware human-computer interaction but not limited to traditional interfaces as the main goal is to, in real-time, mold and provide dynamic multimedia content that fits the audience emotional needs. In order to pursue this aspiration, and based on the described state of the art summary, the Russell's bidimensional model of affect is reused and adapted; GSR, skin temperature and respiration volume and rate sensors are used as biosignals to perform real-time emotion assessment through fuzzy sensorial fusion and the outcome is integrated into a flexible multimedia content generation and distribution modular framework.

3 BIOSTORIES DESCRIPTION

The key design principles and requirements are identified and listed below: Complete architecture component modularity to ensure full freedom to parallel development and path reversal possibility, always critical in exploratory courses of action; Biometric channels composition flexibility degree maximization so that diverse conjugations could be experimented to guarantee several emotional assessment scenarios and promote third-party suppliers independence; Stakeholders' geographic and logical distribution possibility as the project contemplates a strong experimental component it has been found imperative that the subjects, coordinators and researchers would have the chance of being apart for allowing controlled environments; Real-time signal acquisition and processing complemented with data storage for posterior analysis to allow online emotion assessment and multimedia distribution but also granting offline critical processing; Third-party software independence maximization to assure that although some hardware solutions have to be adopted the whole architecture shall not be limited or constrained by external entities. The conducted state of the art revision, specially the one dated from the beginning of the research, showed the absence of such framework ready for adoption (Vinhas, 2008). As a natural consequence, the decision was to develop the envisioned platform following the enunciated principles that resulted in the design presented through Figure 1 (Vinhas, 2009).

The framework description might be done by following the information flow in a cycle. So, first to the end user a given multimedia content is presented and several biometric signals are collected from one or various equipments. In Figure 1, as example, there have been referred three distinct channels each one with a different data communication interface for illustrating the framework versatility. For every channel a software driver has been developed to ensure independency and the collected data is further made available through a TCP/IP network from where different client applications can connect and online access and process information. This approach copes with the physical and logical stakeholder's independence and distribution.

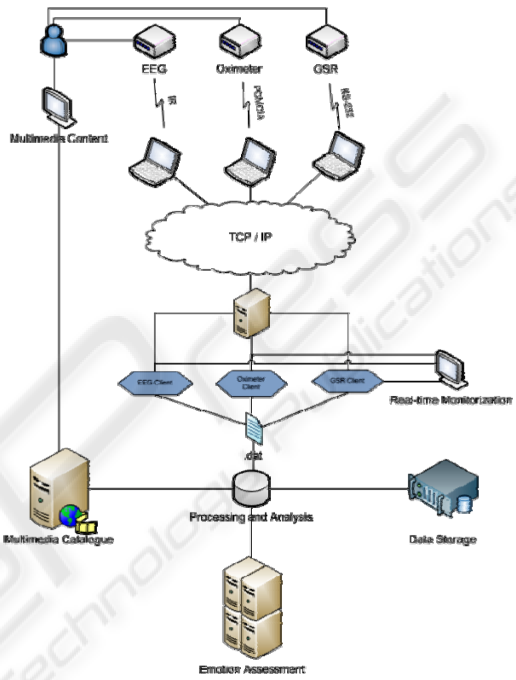

Figure 1: BioStories Global Framework Architecture Diagram.

At this end of the architecture, there is a client for each biometric channel responsible both for pre-processing activities and enabling real-time monitoring. Their outputs are the input for the processing and analysis backbone responsible for data storage, emotion assessment and combined with the emotional policy, choose from the multimedia catalogue or generate the next multimedia content to be provided to the end user.

The process of performing online emotion assessment and its conjugation with the emotional policy in order to influence the storyline is object of depiction in the subsection devoted to BioStories, where it is also visible the maintenance of the architectural structure across all developed prototypes, including the spin-off projects.

The initial stage of the research was unsurprisingly characterized by the definition of the already detailed framework and early biometric equipment acquisition. Within this scope EEG and heart rate acquisition hardware solutions were purchased, namely Neurobit Lite™ and Oxicard®. While the first ensured high portability levels alongside with high usability levels, infrared data transmission and API disclosure for driver development; the second was caracterized by reduced dimensions, high perfusion degree and also API disclosure, thus enabling independent software design.

During the preliminary experiments conducted with the EEG equipment, due to an unforeseen active electrode positioning protocol error, EMG signals started to be registered due to its location in the user's temporal zone, between the eye and the ear. As the signal pattern was so distinct and clear, it was taken the decision of spinning off this opportunity as an alternative interaction research track based on intentional eye closure detection (Gomes, 2008).

The basilar project principle was to provide a simple yet effective method for wink detection and map this into external actions in a way that it could be faced either as in inclusive human machine interface for disabled people or an alternative interaction mechanism as an extension for traditional interfaces. Another important premise was the need to keep the assessment algorithm straightforward enough to be computed in embedded systems without serious processing effort.

This design resulted in the definition of an algorithm based on the establishment of two threshold parameters: *peak* and *duration*. The first parameter represents the minimum signal amplitude value so that intentional eye closure action might be present. Only values above such limit are considered to be potential winks. The *duration* parameter refers to the minimum time span that the signal must persist above the *peak* limit to complete the action detection process and, therefore, assign wink recognition. Once the signal processing assessment procedure is conducted and wink recognition is online performed, there is the need to trigger the corresponding external action, result of the interface purpose. This is been achieved by click operations and drag mode activation emulation. These actions were tested using the computer card game Microsoft Hearts which experimental results are reserved to the appropriated point in the following section.

Following the successful approach, the detection methodology has been extended to contemplate both differential and conjunction eye analysis, thus enabling left from right wink detection as well as single from both eye intentional closure. This has been performed by setting two extra pairs of *peak/duration* parameters, necessarily lower for the non-dominant eye and higher for both eyes. Although standard parameter values are suitable for most users, there is the possibility to tweak and fine tune these in order to maximize classification success rates.

Further considerations referring to this research line are due to the results and critical analysis sections, as the main BioStories track, namely the emotion assessment and online multimedia generation are depicted in the following subsection.

The main track research project designated as BioStories has known several prototype versions. The results achieved in one approach were analyzed and the extracted conclusions were incorporated in the next version until the final approach, now subject of detail.

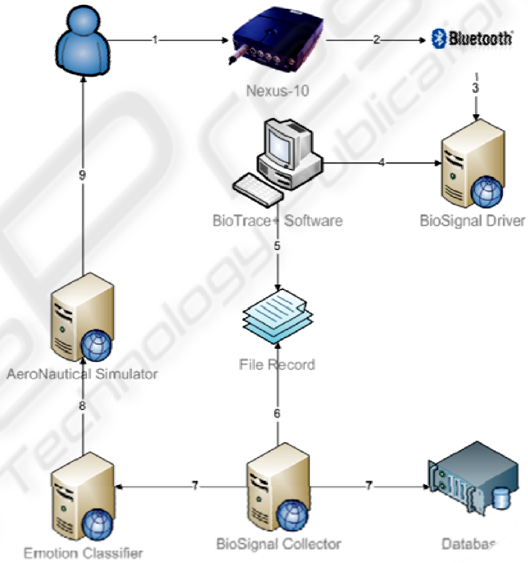

Figure 2: Framework Architecture Instantiated to BioStories 3D Immersive Environment Prototype.

Having this in mind, and undertaking just a swift contextualization, the initial approach was based on EEG signal analysis complemented with GSR data. It was found that subject gender alongside with high-frequency EEG constituted key factors for emotion assessment (Teixeira, 2008). These findings were further explored in the first automatic emotion assessment attempt based on data pre-processing techniques together with offline cluster analysis (Teixeira, 2008). As for enhancing the EEG data collected multichannel equipment needed to be acquired with both invasive and financial impact, it was chosen to use GSR, respiration and skin temperature sensors to perform real-time emotion assessment. In order to close the information loop, IAPS Library was used for multimedia content supply (Vinhas, 2009). This prototype version was further improved by replacing the still images for dynamic multimedia content and refining the emotion assessment methodology (Vinhas, 2009). The described evolution has now taken the final step with the latest BioStories prototype that enhances both emotion assessment and multimedia immersiveness levels.

Starting the project description by the framework architecture instantiation, it is completed based and adapted from the original one, as illustrated through Figure 2. The main differences reside in the biometric channels and equipments used. In this version, Nexus-10 hardware solution was elected as it congregates the simultaneous collection of ten distinct channels in a compact portable unit with data communication based on wireless Bluetooth protocol thus granting complete software independence. For this version, there have been used as biometric channels: GSR; respiration sensors for acquiring volume and rate; and skin temperature.

The remaining system components are very similar to the previously described architecture with the multimedia catalogue being replaced by an aeronautical simulator responsible for tridimensional environment generation and control – in this case Microsoft Flight Simulator X. In order to promote greater immersiveness levels, although not depicted in Figure 2, there have been used tridimensional goggles with three degrees of freedom – roll, pitch and yaw – from Vuzix iWear.

It was found useful to employ Figure 3 as a reference for module interaction description, as it represents a running screenshot of the main BioStories application: the *Emotion Classifier*. First it is necessary to establish the connection to the *Collector* for accessing online biometric data feed; setting the link to the aeronautical simulator for real-time environment parameterization; and finally and optionally connect to a local or remote database for processing data storage.

On the bottom of the screen there are two separate areas for signal monitoring: the one on the left provides the latest data collected and the one on the right allows for baseline and interval definition for each channel. In the middle of the screen, there is the emotional policy control panel where session managers are able to determine which emotional strategy shall be activated from contradicting or reinforce current emotional state, force a particular one or tour around the four quadrants. Specifically related to the emotion assessment methodology, the dynamic chart on the right allows for real-time user emotion monitoring as the big red dot stands for the initially self-assessed emotional state and the smaller blue dot for the current one. The classification process is based on sensorial fusion on top of the bidimensional Russell's circumplex model of affect, depicted in the state of the art section. The whole process resides in the calculus of *valence* and *arousal* values, being the first responsible for the *horizontal* emotional movement across the *x-axis* from *displeasure* to *pleasure* states; and the second accountable for *vertical* emotional displacement across *y-axis* from *low* to *high* excitement levels. With the purpose of pre-processing data towards real-time emotional assessment, a normalization process is conducted so that both *valence* and *arousal* values are mapped into the [-1,1] spectrum. With this approach, emotional states are faced as Cartesian points in a bidimensional environment.

Considering the mentioned normalization process, it is important to detail the already superficially mentioned calibration process. In spite of any given Cartesian point represents a normalized defined univocal continuous emotional state, it can be the result of an infinite number of biosignals conjugation.

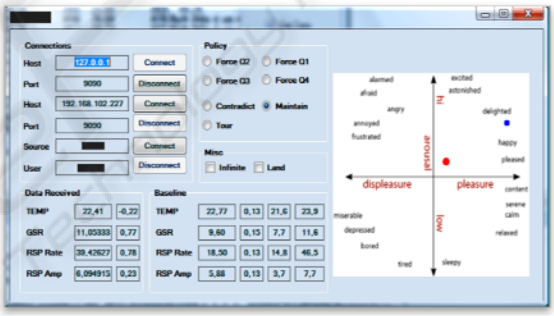

Figure 3: BioStories Running Application Screenshot.

Equation 1: Dynamic Biometric Data Scaling Model.

$$(a) c_1Max = MathMax(c_1Max, Sample[c_1Index]$$

$$(b) c_1ScaleUp = 1 - baselineNorm.Axis/c_1Max.baseLineSample[c_1Index]$$

$$(c) c = Sample[c_1Index] - baseLineSample[c_1Index]$$

$$(d) c_1Norm = baseLineNorm.Axis + c_1ScaleUp \times c$$

This evidence alongside with the extreme biosignals baseline definition discrepancy between two people or even for the same individual across time – either due to morphologic differences or context variations such as sleep time and quality, erratic food habits or external weather conditions – leads to the absolute need for a standard calibration and biometric channels fusion.

The calibration is performed through a self-assessment process at the beginning of the session, although it can be repeated without limitation also during the experimental protocol, by directly pinpointing the predominant current emotional state. This action enables the definition of the normalized baseline point according to the real-time assessed biometric information and for each channel it is considered an initially non binding twenty percent signal variability allowance. Whenever overflow is detected, the dynamic scaling process is activated as illustrated through Equation 1 and might be summarized as the stretching of the biometric signal scale when normalized readings go beyond the interval of [-1,1]. This process is conducted independently for each of the channels and results in a non-linear scale disruption, ensuing in a greater density towards the limit breach. First, c1 – any given biometric channel – maximum value is determined by comparing current reading with the stored value – Equation 1(a). If the limit is broken, the system recalculates the linear scale factor for values greater than the baseline neutral value, having as a direct consequence the increasing of the interval's density – Equation 1(b). Based on the new interval definition, subsequent values shall e normalized accordingly – Equation 1(c)(d). With this approach, and together with dynamic calibration and data normalization, it becomes possible for the system to perform real-time adaptations as a result of user's idiosyncrasies and signal deviations, thus assuring continuous normalized values.

Considering the aeronautical simulator as a tridimensional multimedia engine, the current emotional state and the target one, determined by the policy, influence the simulation parameters, namely weather conditions, scenery and maneuvering. The two quadrants associated with displeasure determine worse climacteric conditions ranging from thunderstorms to fog to cope with high or low levels of arousal. Fair weather conditions are associated with the two quadrants related to pleasure. The main routes are configurable and there have been designed two courses: one very simple that consists of an oval-shaped route around an island, and the second with many closed turns at low altitudes. Also maneuvering is controllable varying speed, heading and altitude swiftly and suddenly for the first route and for the second one applying additional features like maximum bank and yaw damper which limits the maximum roll during turns, and reduces rolling and yawing oscillations, making the flight smoother and calmer.

4 EXPERIMENTAL RESULTS

In order to assess the adequability of the proposed approach for human computer interaction objectives, the following experiment was designed relating to the mouse control through EMG. Thirty volunteers selected from fellow laboratory researchers and college students were randomly divided into two groups. Group A emulated trained and experienced end users with basic technology knowledge and Group B represented inexperienced users without any previous knowledge or contact with the system.

To the first group elements there have been given the opportunity to try the prototype for ten minutes after a short theoretical formation while the second group elements jumped straight to the validation experiment. The session consisted in the users performing ten intentional dominant eye closures – or the system classified as winks ten actions as result of false positives.

The thirty sessions result distribution, divided into the two groups, showed the positive impact of the initial contact with the technology and system as well as performing parameter fine tuning. Nevertheless it also shows that the learning curve is easily beaten, stating high usability levels and user adaptation. The trained users group reached a mean success rate of ninety percent with the minimum value of sixty five percent with some error free records. The lack of training prevented such success levels as the mean assessment success rate is less than seventy percent with values varying between twenty five and eighty percent.

These results corroborate the initial hypothesis that stated that electromyography could be used through a simple approach with low computer resources consumption as a technique to perform effective, inclusive and alternative user interfaces. The conducted experiments also pointed to the positive impact of user training and technology familiarity without requiring overcoming a hard learning curve slope. This spin-off effort also resulted in filing a patent.

Considering the BioStorie's main track, both Table 1 and Table 2 condense by means of confusion matrixes the results of automatic emotion induction and assessment, respectively. Both perspectives are based in the discretization into the four basic quadrants of the Russell's circumplex model and the user self-assessment is directly compared to the described automatic process – in the induction method emotional policy is used instead and reports to IAPS Library based prototype (Vinhas, 2009). The induction process overall results

Table 1: Automatic Emotion Induction Confusion Table.

		Emotion Induction			
		1st Quadrant	2nd Quadrant	3rd Quadrant	4th Quadrant
Users	1st Quadrant	**20%**	7%	0%	1%
	2nd Quadrant	3%	**9%**	1%	3%
	3rd Quadrant	1%	6%	**19%**	4%
	4th Quadrant	1%	3%	5%	**17%**

point to a success rate of sixty-five percent, greatly due to the lack of second quadrant precision as some pictures were considered context and cultural dependent.

In what regards to the emotion assessment based on the proposed fuzzy sensorial fusion, and taking into account the tridimensional virtual aeronautical environment, the global success rate achieves almost eighty-seven percent with most users facing the experience with high arousal levels as seventy-one percent of the situations were self-assessed in first and second quadrants. The emotion classification error was distributed in a fairly linear fashion.

Taking into account the second subject, the simulation engine acted as predicted allowing for full context control and route definition. With direct correspondence with the emotional response and assessment all the accessed simulation parameters initially enunciated such as weather conditions, routes and general maneuvering controls were successfully dynamically accessed and tweaked in real-time as SimConnect API from Microsoft Flight Simulator X acted as predicted while being integrated into the projected base framework as an additional module.

Table 2: Automatic Emotion Assessment Confusion Table.

		Automatic Assessment			
		1st Quadrant	2nd Quadrant	3rd Quadrant	4th Quadrant
Users	1st Quadrant	**30,7%**	1,8%	0,3%	1,2%
	2nd Quadrant	3,1%	**32,8%**	1,0%	0,1%
	3rd Quadrant	0,2%	1,7%	**10,9%**	1,2%
	4th Quadrant	1,0%	0,1%	1,6%	**12,3%**

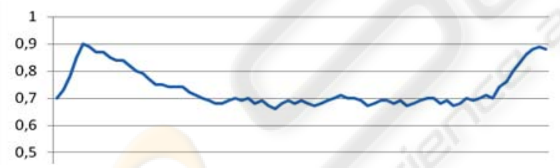

Figure 4: Average Arousal Levels During Simulation.

Between the simulation and the integration topic, it has been conducted a survey amongst the twenty one subjects – thirteen males and seven females, aging between twenty one and fifty six – in order to assess the immersiveness level of the whole experiment – that consisted in three sequential stages from take-off, fifteen minute cruising and the final landing phase. The results showed an average classification of four point two score out of five with a minimal classification of three, thus demonstrating a significant success in providing realistic immersive environments greatly potentiated by the used tridimensional tracking eye-wear.

As take-off and landing are traditionally associated with higher apprehension and anxiety levels amongst passengers, it has been conducted a specific arousal monitoring across the simulation sessions. The results are depicted through Figure 4 that exposes the predicted peak zones with high normalization latency after take-off, therefore strengthening the realism assessment conducted in the course of the referenced survey.

Considering the last topic, dedicated to integration and information loop completion, one must refer to the absolute framework reliability and flexibility across the latest prototype development and test. It has accommodated the dynamic change of biometric channels with distinct hardware solutions and has coped efficiently with data communication distribution and analysis in real-time as well as enabled full third-party integration and modular operability. Finally, it has been confirmed the complete information loop closure, since initial multimedia presentation, biosignals acquisition, distribution and processing, real-time emotional state assessment and online multimedia content generation and further cycle iteration.

The latest prototype and approach took advantage of multimedia presentation reformulation as well as greatly enhanced both multimedia realism and emotion assessment proposed methodology by enabling continuous and discrete emotional state definition and monitoring.

5 CONCLUSIONS

The single fact of the framework design being able to cope with the distinct BioStories prototype versions alongside with its usage to support spin-off projects, proved that the initial option to develop from scratch a common support framework was a successful call. All of the initially proposed functional and non-functional requirements were totally met, thus accomplishing a stable yet flexible and dynamic test bed and an innovative standalone human computer interaction platform. These achievements might be instantiated by means of the complete architecture modularity as all its components are strictly compartmented therefore enabling extreme physical and logical stakeholders distribution. On top of this, it has been attained an extremely plastic biometric channel set and emotion assessment method allows for diverse combinations according to environment conditions while assuring manufacturer and third-party independence. Finally the possibility or performing real-time emotion assessment while storing the raw collected data for posterior analysis alongside with multimedia content generation and distribution constitute a powerful cornerstone of the whole research project.

Still in the initial subject, it is worth to examine the results attained by the most significant spin-off project, namely the mouse control through electromyography. This prototype as a proof-of-concept demonstrated that a simple minimal invasive approach using EMG to perform intentional eye close action detection was able to achieve high hit ratios while having a negligible impact in user's environment. Its practical appliance to emulate discrete mouse movements and clicks verified the possibility of constituting a stable interaction paradigm both for inclusive proposes for disabled people but also as an extension for traditional user interfaces whenever manual usage is not advisable or already overloaded.

The results presented concerning BioStories confirmed the initially enunciated hypothesis that multimedia content could be generated and/or the base storyline could be dynamically changed directly according to the audience emotional state assessed in real-time by means of biometric channel monitoring. Equally, the emotional model, adapted from Russell's circumplex model of affect, confirmed its ability to realistically represent emotional states in a continuous form while enabling their discretization. Specifically in what concerns the emotional assessment methodology, the proposed approach based on sensorial fusion with high levels of personalization enhanced individual and temporal biosignals independence and adaptability. Still in this particular domain, this dynamic method allowed for high levels of flexibility in what concerns biometric channel set definition, thus permitting further developments and system employments.

Taking into account the multimedia content division of the project, earlier BioStories prototypes illustrated that the usage of still images did not provide the needed immersiveness for strong and evident emotions, thus the latest option being concentrated continuous environments distributed through immersive goggles. The achieved results showed that this proposal was effective and the method for scene generation alongside with the content visualization method provided the levels of immersion and realism required for triggering and sustain real emotional responses.

Probably the most immediate application of the proposed technology is the videogame and virtual entertainment industry. The possibility of real-time rich immersive virtual dynamic environments – as this domain is defined – in conjunction with online user emotional state retrieval constitute a perfect fit for this approach. On top of these factors, traditional end users offer little resistance in adopting new enhancing interaction solutions. Another positive factor resides in that the system could be designed for single user and single distribution as multiplayer platforms are greatly online based. The greatest challenge in this application is believed to be the biometric hardware miniaturization without signal quality loss in a way that they could be integrated into a single electronic consumer good.

The second line of prospect resides on the cinematographic industry. In this case the challenges are much different as the multimedia contents are not continuous but discrete and thus generating tree storylines has an economic impact as further scenes need to be shot but as the film depth and amplitude would be enhanced it is believed that these hurdles could be suppressed as the content would not expire in a single view. From a technical stand, it is also needed to define if the content distribution is to be individualized or centralized in a common screen just like nowadays. The first option enables full individual content adaptation but prevents the traditional cinema experience, while the second does not allow for fully individualized emotional control. Regarding the emotion assessment process, as attaching physical equipment to all the audience is not feasible, it is envisioned the usage of intelligent seats equipped with position sensors as well as infrared cameras for skin temperature and body position evaluation.

As a natural extension of the previous point, digital television arises. The advent of bidirectional communication opportunity in digital television has been, until the present day, modestly explored and confined to basic interaction mechanism such as televote or programming guide description. It is believed that the appliance of the proposed approach would enable the exponentiation of these levels allowing greater dynamism in recorded contents and, above all, promote real-time programmatic changes to live content according to the online audience response. One can image its massive impact when addressing advertising, editorial line options or political impact of declarations and news. The promoted changes with this technology would instigate the creation of a TV2.0 replicating the huge leap forward taken by the designated Web2.0. The technologically challenges are in the middle of the first and the second domains, as they can be tackled from a controlled personalized environment but the hardware solutions must be as minimal invasive as possible.

Direct marketing applications might start precisely with its appliance to digital television. As soon as marketers have access to costumers emotional states, specific designed advertisements can be developed and distributed exactly to match a particular emotion profile in order to potentiate campaign returns. In these alternative scenarios it would be needed the development of non invasive solutions based on video monitoring and real-time location systems in a complementary way of that exposed in the cinematographic domain.

In order to bring to a close the identification of future work areas and application opportunities, one shall point the chance to apply this approach to medical procedures in general, and in psychiatric procedures, in particular. The patient's emotional state knowledge by the physician is a valuable key both for diagnostic and treatment proposes. This statement is even accentuated when referring to psychiatric domains such as phobias and depression. On the other hand, there is a need for stricter and more reliable emotion assessment even if real-time can be sacrificed, thus classification methods are on the line for improvement as future work research lines in this scope.

As a final remark, it is important to distinguish the quantity and diversity of potential practical application of the proposed approach and technology thus enabling several research lines opportunities with a potential colossal impact not only, but with a special focus, in the field of human computer interaction.

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