Augmented Sport: Exploring Collective User Experience

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ABSTRACT
This paper explores existing theories, frameworks and models for handling collective user experience in the context of Distributed Interactive Multimedia Environments (DIME) and more specifically Augmented Sport applications. Besides discussing previous experimental work in the domain of Augmented Sport, we introduce Future Media Internet (FMI) technologies in relation with Mixed Reality (MR) platforms, user experience (UX), quality of Service (QoS) and quality of Experience (QoE) within 3D Tele-Immersive Environments that are part of the broader DIME domain. Finally, we present the 3D LIVE project QoS-UX-QoE approach and model that will be applied along three use cases (Skiing, Jogging and Golfing) experiments for anticipating the potential user adoption.

Categories and Subject Descriptors
H.5.1 [**Information interfaces and presentation**]: *Multimedia Information Systems* – artificial, augmented, and virtual realities, evaluation/methodology. H.5.1 [**Information interfaces and presentation**]: *User Interfaces* – graphical user interfaces (GUI), User-centered design.

General Terms
Design, Experimentation, Human Factors, Measurement, Performance, Theory.

Keywords
3D-Media; Tele-Immersion; Mixed Reality; Augmented Reality; Virtual Reality; User Experience, Living Lab; Experiential Design; Future Internet; QoS; QoE

1. INTRODUCTION
A previous paper [1] introduced the 3D LIVE project vision specifically addressing 3D Tele-Immersive Environments (TIE) and willingness to apply the Living Lab approach for engaging users in the R&D process in order to co-create, explore, experiment and evaluate Augmented Sport applications in the context of Future Media Internet (EXPERIMEDIA) Testbeds. This vision fits with the "Consumer Innovation" trend that was recently studied by Von Hippel and colleagues [2]. Besides introducing the iterative Experiential Design process and Living Lab ecosystem, the 3D LIVE platform was presented as well as 3D Real-Time Reconstruction and Activity Recognition [3, 4].

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Such Augmented Sport applications are extremely demanding in terms of broadband Internet performance requiring 4G (LTE) or high capacity Wi-Fi wireless networks or FTTH wired networks. This second paper, besides discussing the two research publication streams on User eXperience (UX) and Quality of Experience (QoE), explore the existing theories, frameworks and models related to the understanding, modeling and evaluating collective user experiences within the context of 3D-TIE for designing 3D LIVE experiments on Augmented Sport scenarios.

2. PREVIOUS WORK
2.1 Augmented Sport
In the previous work related to Augmented Sport there are numbers of empirical studies on different technology platforms that were conducted through experimentation involving participants as sport players. They also followed an iterative design process were they were confronted with user reactions.

According to Mueller and Agamanolis [5, 6, 7], computer games lack both the social bonding and collective physical exercise that

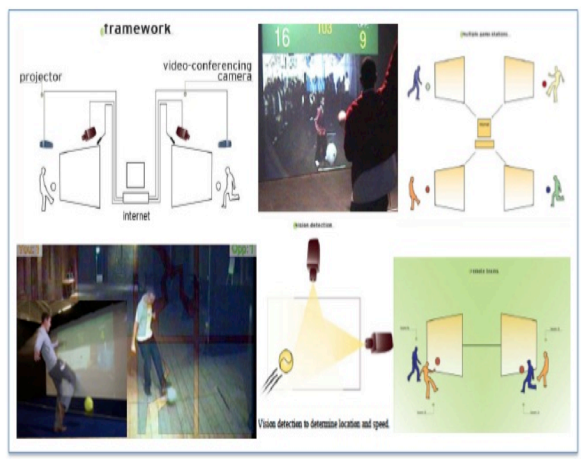

Figure 1. Sports over a distance [7].

sports do provide. They investigate how it could be possible to get these sport's benefits, especially the workout and socializing effect, in a distributed setting. Beside the thousand players who interacted through a life-size video-conferencing screen using a regular soccer ball as an input device, Fifty-six were interviewed. They expressed that they got to know the other player better, had more fun, became better friends and were happier with the transmitted audio and video quality in comparison to those who played the same game using a non-exertion interface. This experimentation of a sport activity over distance was intended to demonstrate the interest of using an exertion interface to exhaust the participants while creating and increasing connectedness among them; the feasibility of having, at least, two players acting at the same time from remote locations; playing sport over a distance is possible. Authors found out that their empirical study on practicing sport activities over a distance opens an exciting new field of research when having an exertion interface encouraging remote interaction where players can achieve both workout and socializing.

Hence, they propose an alternative solution to turn sports over a distance into a reality in inventing new sport games that still utilize a ball as an interface. They created "Breakout for Two" as an amalgam of soccer, tennis and computer game (see Figure 1).

As described in the Table 1 reference S9, "*The players, who can be miles apart from each other, both throw or kick a ball against a local, physical wall. There is a projection of the remote player on each wall, enabling the participants to interact with each other through a life-sized video and audio connection.*"

In fact, the wall separating the two players represents the net while they occupy their part of the field. Authors claim that the experience is like being on a tennis court. Furthermore, the two players can interact vocally as they can permanently talk to and see each other, which facilitates the social interaction and encourage conversations like challenging the other player or confronting winning strategies. Players reported that they felt like being separated by a glass window as the ball once kicked bounced back from the wall.

In terms of results, exertion game players rated the interaction with their new game partner higher in contrast to the non-exertion players using a keyboard. Interviewed participants found that they got to know the other player better, had more fun, became better friends, and, surprisingly, were happier with the transmitted audio and video quality, although the quality was identical between the two games. They also recognized that it was far more exhausting that they initially thought it would be.

Interestingly, it is reported that some participants were so much embedded in the game action (immersed) that they were seriously out of breath. Unfortunately, it is not mentioned whether the social interaction had any impact on the degree of immersion while it seems quite clear that it had a real impact on the satisfaction of the participants.

"Breakout for Two" was demonstrated at NextFest'2004 in San Francisco, an annual technology world fair organized by Wired Magazine that attracted 24,000 visitors in three days. This version included a timer that limited the game time in order to cope with the rush of visitors. Another important aspect worth to be mentioned is the fact that participants rarely criticized system inaccuracies while the vision detection did not always work properly. It appears that participants of different age understood that it was a social game; hence there was no blame among players for the defeat. Even a cultural difference appears between European and US participants as the first ones kick the ball with their feet while the second mostly preferred to throw the ball with their hands.

In conclusion, authors were satisfied with their exertion interface demonstrating that it provided a valuable augmentation to what current interfaces try to achieve in terms of social interaction. Finally, they argue that sports practiced over a distance on the one hand support people connection on a social level and on the other hand encourage people to physically exercising while the current trend is far more leading towards the removing of any substantial physical effort. There are other Augmented Sport experiments that were previously conducted (see Table 1)

Table 1. Previous Work Related to Augmented Sport (extended from [7])

Seq	Sport/Game	Reference	Description
S1	Dance Revolution	(Komani, 2005) [50]	A physical dance game
S2	Air-Hockey (AR2)	Ohshima et al., 1998 [51]	Augmented reality air-hockey table
S3	Air-Hockey over a distance	(Mueller et al., 2006) [52]	Augmented reality air-hockey
S4	Foosball	(Kiro, 2005) [53]	A robotic foosball table
S5	Fly-Guy	(Wulf et al., 2004) [54]	A hang-glider controlled with body movements
S6	Tug-of-War	(New York Hall of Science, 2004) [55]	A group physical activity
S7	Net-Gym	(Brucker-Cohen and Huang, 2005) [56]	Exercise bicycles in a virtually connected gym
S8	Virtual Fitness Center (Virku)	(Mokka et al., 2003) [57]	Exercise bicycles in front of a video screen.
S9	Snow-wars	(pLAB-Snowwars, 2003) [58]	Simulates a snowball fight
S10	Breakout for Two	[7]	Throw or kick a ball against a wall
S11	Outdoor Skateboarding	(Anlauff et al., 2010) [59]	Outdoor skateboarding
S12	Skateboard Trick	(Reynell and Thinyane, 2012) [60]	Skateboard visualization on a mobile phone
S13	Bouncing Star	(Izuta et al., 2010) [61]	Augmented sports application using a ball
S14	Virtual Archery	(Göbel et al., 2010) [62]	A virtual archery experience
S15	Immersive Ball Game	(Greuter et al., 2011) [63]	Immersive Ball Game
S16	Skiing Gravity Center	(Hasegawa et al., 2012) [64]	Real-Time sonification of the center of gravity
S17	Interactive Gaming	(Bleiweiss et al., 2010) [65]	Enhanced interactive gaming

2.2 Future Internet and Media Technologies

Today, the Internet is widely used for globally communicating and disseminating information; it regularly opens new doors to human creativity and brings opportunities for diverse innovations (e.g. Internet of Things, Internet of Services). There is a limitless amount of available online resources and tools to share information and increase the understanding about any specific topic. It is often predicted that the Future Internet (FI) will dramatically broaden both the range of available information and the user's potential contexts and situations [8].

From a technological point of view, the Internet evolves concurrently with many research streams such as peer-to-peer, autonomous, content-centric and ad-hoc networking as well as service and cloud computing that have already explored improvements on network performance, quality of service and user experience [9]. Peer-to-peer networking has demonstrated both the feasibility and economic potential for delivering services to millions of users. Cloud Computing is a more recent paradigm, which allows to transparently sharing among users scalable elastic resources over a limitless network, expected to have a significant economical impact.

However, a wide empty field exists between the technology orientation of Future Internet research and citizens' expectations. Hence, the concept of open and user-driven innovation ecosystem, such as the Living Lab approach, brings the necessary combination of digital skills, creativity and innovation methods that properly bridge the gap between technology push and Application pull. Extending still furthers the benefits and application of the Living Lab approach; the EXPERIMEDIA project [10] expands the context of Future Media Internet (FMI) experimentation into large-scale venues. Deployment, integration and testing of innovative FMI technologies across a wide area can be challenging for any single organization. EXPERIMEDIA seeks to accelerate this process through the provision of both exciting, well-regarded venues and a range of FMI oriented 'baseline' software, services and access to on-line communities upon which experimenters can build. The initial venues selected by EXPERIMEDIA include the Schladming Ski resort; the multi-sport high performance center of Catalonia; and the Foundation for the Hellenic World, Athens. Between them, they represent a diverse range of real and virtual environments in which new FI technologies can be synthesized with leisure, sporting and cultural experiences. Baseline technologies provided by EXPERIMEDIA include production quality and user-generated video streaming and composition services; pervasive gaming and augmented reality technologies; mobile QoE sampling technology; and on-line social network community analytics.

2.3 User Experience

User experience, abbreviated UX, is a concept describing the experience people have in interacting with a particular product or service, its delivery, and related artifacts, according to their design. ISO 9241-210 defines user experience in the following way "*User Experience is a person's perceptions and responses that result from the use or anticipated use of a product, system or service*".

The ISO definition describes user experience as all users' emotions, beliefs, preferences, perceptions, physical and psychological responses, behaviors and accomplishments that occur before, during and after the use of product, system or service. It is also mentioned that the type of product, system or service, user profile and the context of use are factors that influence user experience.

Scapin [11] argues, UX has become very popular, has several meanings, with a varying and complex coverage of topics and issues, and is very subjective [12] and versatile by nature. According to Kankainen [13], the versatility of UX could be explained by the fact that a person holds previous experiences that could be altered by a new experience, hence increasing the level of expectation for the next occurrences.

As proposed by Pallot and Pawar [14], the generic approach of the holistic UX model is a "Top-Down&Bottom-Up" model of different type of experience (see Figure 2).

Most of the UX descriptions issued in the Human Computer Interaction (HCI) and Interaction Design scientific domain refer to UX as a combination of People-System-Context and focus on the interactions between an individual and the product/service mentioned as the system. However, this People-System-Context approach simply ignores the interactions among people and the interactions of people with their environment. In contrast, our approach of UX is to take into account all types of interactions as described in the product ecology framework [15] and especially the ones that are supported by IoT based products/services.

2.4 QoS and QoE within 3D-TIE

Few years ago, Wu and colleagues [16] described a user-centric QoE conceptual framework for the area of distributed interactive multimedia environments as he found the existing evaluation frameworks very much system-centric despite the intensity of user-involved interaction. This QoE theoretical framework is expected to help model, measure and understand user experience (UX) as well as the relationship with QoS metrics. This framework is based on theoretical results from different fields of research, namely: psychology, cognitive sciences, sociology and information technology. They use a mapping methodology to quantify the QoS and QoE correlations.

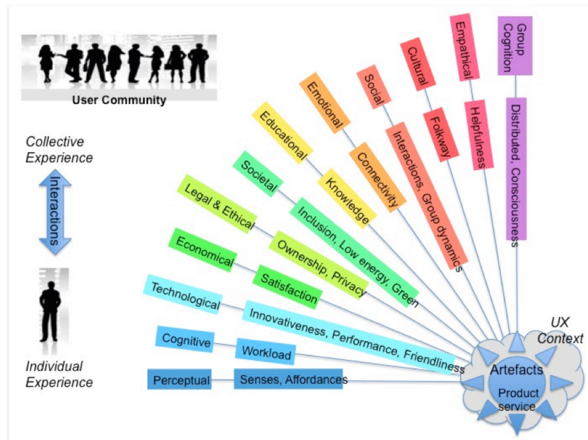

Figure 2. The Holistic View of UX [14]

Authors identify 3D Tele-Immersion (3DTI) comparable to video-conferencing and multi-player gaming environments in terms of highest level of user interaction. It is important to note that it is not only about user interaction with the technology but among the users through different communication channels. Even more important, they emphasize that empirical findings have shown that systems excelling in the QoS area can completely fail with the user adoption due to the remaining gap between system and user centric evaluations [17].

Wu and colleagues represent QoE as a multidimensional construct of user perceptions and behaviors where the QoS-QoE relationship is a causal chain of the following sequence: "*environmental influences* (QoS) -> *cognitive perceptions* -> *behavioral consequences* (QoE)" [18]. Their definition of QoE is the following: *"QoE is a multi-dimensional construct of perceptions and behaviors of a user, which represents his/her emotional, cognitive, and behavioral responses, both subjective and objective, while using a system."*

Figure 3 illustrates QoS metrics as environmental factors that influence QoE while there is also a feedback loop from QoE to

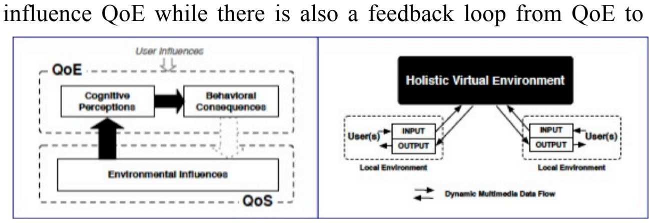

Figure 3. Causal Chain in the QoS-QoE Framework and Communication Model [16]

QoS (dashed arrow) as users' requirements and responses may drive the QoS configuration. Authors explore the QoS-QoE mapping (correlation) methodology through the empirical studies of a 3DTI system. The holistic virtual environment (see Figure 2) represents the 3DTI systems relying on Real-Time multi-view 3D video as the 3D representations of remote users are immersed into a virtual space allowing body movement interactions.

3. 3D LIVE User Experience Model

3.1 Influential Factors and Layers

Within the 3D LIVE project, the user experience is situated in the context of Distributed Interactive Multimedia Environments. Hence, the aspect of social interaction among players and followers lead to collective user experience rather than only individual user experience. Furthermore, the 3D body reconstruction of players may also have an impact especially on the collective user experience depending on the degree to which users feel more immersed.

There is a wide range of factors influencing an individual or collective user experience that were previously identified and classified within three categories, namely: the context of usage, the users' state and system properties [19]: **Usage context**: It refers to the specific situation in which users are operating as a place, time, interaction, task and information infrastructure (e.g. on the move, within a group of people, using a smart-phone, Internet connection). **Users' state**: It refers to motivation, mood of the day, expectations and current mental and physical shape. **System properties**: It refers to the system functionalities, interactiveness, responsiveness and aesthetic as well as brand reputation (e.g. coolness, reliability).

Two 3D LIVE internal workshops allowed project partners to draft, for the context of 3D TIE, a table of user experience model elements and properties that are classified by type of experience/value created. This list is based on the previously described holistic model of user experience in the section 2.3 where only the elements appropriate for a 3D TIE were selected according to the three use cases (Skiing, Jogging and Golfing). Therefore, it represents an instantiation of the holistic UX model for addressing 3D Tele-Immersive environments that is included in DIME (Distributed Interactive Multimedia Environment).

However, looking at influential factors, beside the already above mentioned three categories, it appears that there are other categories, such as cultural, experiential (prior experiences) and environmental factors (indoor/outdoor) as listed by Wu and colleagues [16]. Figure 4 depicts the sequence from Influential Factors to the building-up of and resulting immersive user experience that are part of the 3D LIVE UX model. In contrast with the Quality Framework in DIME [16], the user experience add the notion of rational and experiential parts. The rational part mainly re-uses the DIME cognitive perception model and the experiential part is based on emotion and intuition. While the DIME quality Framework is based on the Fishbein and Ajzen's [20, 21] Theory of Reasoned Action (TRA), the CEST approach is rather based on the Epstein's [22, 23] Cognitive-Experiential Self-Theory (CEST) on the dual-process model of perception.

In fact, CEST is based on the idea that people operate in using two separate engines for information processing, namely: analytical-rational and intuitive-experiential. While the first one operates deliberately, slowly but logically, the second one operates quickly, autonomously (as a reflex) but emotionally/intuitively. These two engines are independent from each other and operate concurrently (in parallel with interactions) for producing behavior and conscious thought [23]. As argued by Epstein, a constant interaction occurs between the two engines during the day-to-day life. The experiential engine, due to its little need of cognitive resources as it occurs outside of the conscious awareness, deals with most of the daily information processing. It leaves most of the cognitive power to the rational engine for dealing on conscious attention.

According to Norris and Epstein [24]: "*The two systems have unique disadvantages as well as advantages. Thus, the rational system, although superior to the experiential system in abstract thinking, is inferior in its ability to automatically and effortlessly direct everyday behavior, and the experiential system, although superior in directing everyday behavior, is inferior in its ability to think abstractly, to comprehend cause-and-effect relations, to delay gratification, and to plan for the distant future. Since each system has equally important advantages and disadvantages, neither system can be considered superior to the other system.*"

People choice for analytical or experiential processing is

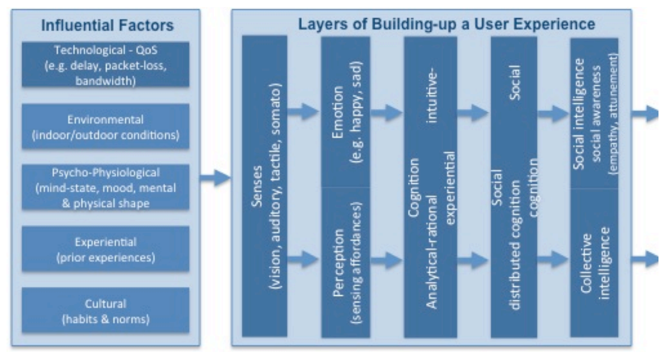

Figure 4. Influential Factors and Process Layers Towards UX

measured through the Rational Experiential Inventory (REI) that uses two factors, namely: need for cognition (rational measure), faith in intuition (experiential measure). Epstein et al. [25] claims that several studies have demonstrated REI as a reliable measure of people difference in information processing. Furthermore, the two independent styles (thinking and feeling) measured account for a substantial amount of variance that is not addressed by other personality theories such as the Five Factor Model [24]. This particular aspect is quite interesting for comparing the processing style of indoor and outdoor players within the 3D LIVE three use cases (Skiing, Jogging and Golfing).

During the GENI Opt-In Workshop, in July 2008, Hoffman and Novak [26] claimed that the synergy between experiential and rational thinking styles creates an emergent nature. It is based on the fact that Novak and Hoffman [27] found that some tasks demonstrate "synergistic effect" where experiential and rational thinking styles [28] correlate positively with performance. Hence, they argued that consumers with an emergent nature score high in rational and experiential thinking style while they do it in a synergistic way. This means that the emergent nature is defined by the interaction between the rational and experiential thinking styles. They demonstrated that consumers scoring high on the emergent nature can co-create product/service concepts perceived by users as significantly better than concepts developed by domain-specific lead users. Therefore, they thought that the concept of emergent nature and the related measurement scale could be a useful instrument in the GENI Web Opt-In project.

3.2 The Rational Part of UX

The Rational Part follows the DIME Cognitive Perceptions model (see Section 3.4); hence it includes the same three elements; except that the Sense of Control from the Psychological Flow is not merge in the ease-of-use of the Technology Acceptance but rather links the two:

- **Psychological Flow**: as for the DIME Cognitive Perception model, Psychological Flow represents the feelings of someone acting with total involvement procuring the perception of great enjoyment and sense of control. Activities such as reading, gaming or sporting provide an intense feeling of immersion as a natural flow of mind. The three metrics identified in DIMEs are namely: Concentration, Enjoyment and Sense of control.
- **Telepresence**: as for the DIME Cognitive Perception model, Telepresence represents users' perceptual Sense of Being within the Distributed Interactive Multimedia Environment that is in 3D LIVE the Mixed Reality environment. In fact, there will be outdoor participants that will be immersed in Augmented Reality and indoor participants that will be immersed in the Augmented Virtuality. Hence, the sense of being or the sense of presence may be totally different depending on being an outdoor or indoor participant.
- **Technology Acceptance**: as for the DIME Cognitive Perception model, the Technology Acceptance (TA) is based on the Technology Acceptance Model (TAM) [29] for considering the technology users' perceptions and attitudes generated by the usage of the technology in use. It is composed of the two believed factors of TAM, namely: perceived usefulness and perceived easiness to use the technology. The perceived usefulness represents the degree to which the user believes that using this technology increase the task performance. The perceived easiness to use represents the degree to which the user believes that using this technology is intuitive enough that it does not require a specific effort. The Technology acceptance and Psychological Flow are linked through the Flow metric Sense of Control.

3.3 The Experiential Part of UX

In contrast with DIME Cognitive Perceptions model (see Section 3.4), the Experiential or intuitive part brings in the emotional and social influences that are essential ingredients of people interactions. Though, Ajzen's Theory-of-Planned-Behavior – TPB – [30], which is the theory about the link between beliefs and behavior further explaining the relationship between behavioral intention and actual behavior than TRA, has also introduced the social influence in order to improve the predictive power of the Theory of Reasoned Action. However, compared to affective processing models, the TPB misses the emotional aspects, such as mood, fear and feeling of-the-day. It includes the following constructs:

- **Social Presence**: According to Griffin [31] several electronic media theories, such as the social presence and media richness or naturalness theories, try to explain the difference between Computer Mediated Communication (CMC) and Face-to-Face communication as well as the lack of social context cues in online communication. The various communication media are classified by the Media richness theory according to the message complexity each medium can effectively and efficiently convey. Kock [32] defines the naturalness of a communication medium, in media naturalness theory, as the degree to which it is similar to the face-to-face medium. He argues that a decrease in the degree of naturalness of a communication medium leads to an increase in cognitive effort and communication ambiguity as well as a decrease in physiological arousal. Social presence theory suggests that CMC restricts users' feeling of having other person(s) involved in the same interaction. It claims that CMC bandwidth is too narrow to convey rich relational messages. Social presence relies on three dimensions, namely: social context, online communication and interactivity. Social context represents the predictable degree of perceived social presence. It involves task orientation and privacy [33] as well as topics [34, 35] but also social relationships and social process [35].
- **Social Emotion**: Social emotions are emotions that require the representation of the mental states of other people. Examples are embarrassment, guilt, shame, and pride. In contrast, basic emotions such as happiness and sadness only require the awareness of one's own somatic state. Therefore, the development of social emotions is tightly linked with the development of social cognition, the ability to imagine other people's mental states. The impact of social emotions in game theory and economic decision-making was already investigated [36]. When people feel a sense of social connectedness to one another, they may experience similar physiological arousal and not only share emotions. Empathy is considered as an affective response emerging from the perception/comprehension of one another's emotional state or condition [37]. The perceived controllability has an important impact on socio-emotional reactions and empathic responses.
- **Emotional Response**: Emotions in virtual communication differ in a variety of ways compare to those in face-to-face interactions due to the inherited CMC characteristics, which may lack many of the auditory and visual cues normally associated with the emotional aspects of interactions [38]. Detecting emotional information begins with passive sensors that capture data about the user's physical state or behavior without interpreting the input. The data gathered is analogous to the cues humans use to perceive emotions in others. Another area within affective computing is the design of computational devices proposed to exhibit either innate emotional capabilities or that are capable of convincingly simulating emotions. Emotional speech processing recognizes the user's emotional state by analyzing speech patterns. The detection and processing of facial expression or body gestures is achieved through detectors and sensors. According to Maruping and Agarwal [39], the increase of emotional cues allows the better detection of negative affect and greater displays of positive affect to counter any negative emotions. Feedback immediacy depends on how quickly messages are transmitted via a particular communication medium and the expectation for which they will be responded. Feedback immediacy allows individuals to more quickly detect and address frustration and other negative emotions. Authors argue that the more synchronous the communication media,

the better for spontaneous comments, such as jokes, which are necessary for positive affect.

3.4 3D LIVE UX and QoE Model

Within 3D LIVE, the Rational and Experiential Model represents the Immersive User Experience (IUX) as supporting instantaneously occurring experience while the Quality of Experience represents the Behavioral Consequences Model including the emotional and empathical responses (see Figure 5). The bottom part of the QoE Model corresponds to the Rational side of the IUX Model while the top part corresponds to the experiential side of the IUX Model.

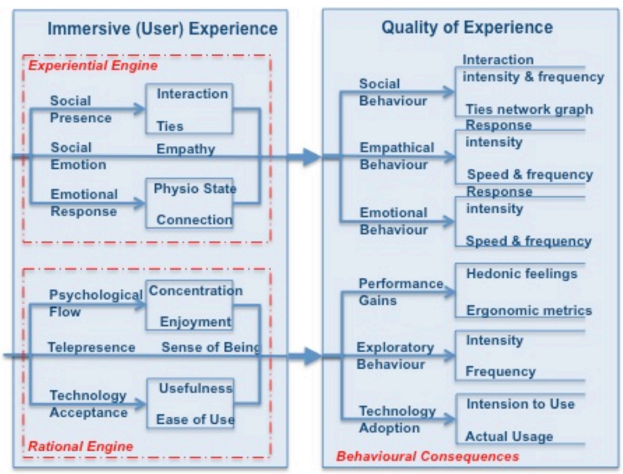

Figure 5. Aligned Immersive Experience and QoE Constructs

The different constructs for the Rational side are described as follow, extended from Wu [16]:

- **Performance Gains**: as for the DIME Behavioural Consequences model, it represents the increase of an individual user's performance for both hedonic (happiness) and ergonomic (effort) values. However, within 3D LIVE, the team (group of users from 2 to mass participation) performance will be considered as well. This can be measured objectively through, for example, a combination of precise metrics such as time recording and percentage of objective(s) achievement(s). These types of metrics are widely used metrics expressed as the ratio of successful attempts and completion time [40]. Furthermore, they would fit perfectly with Augmented Sport applications such as the 3D LIVE three use cases (Skiing, Jogging and Golfing). Like for the DIME Behavioural Consequences model, it is hypothesized that cognitive experience is positively correlated with performance gains.

- **Exploratory Behaviour**: as for the DIME Behavioural Consequences model, it represents the curiosity motivational motor for exploring spontaneously the technology at hand without any particular plans or objectives. This can be measured objectively, through, for example, the amount of playing time and the intensity as well as frequency. Like for the DIME Behavioural Consequences model, it has been shown that cognitive perceptions are positively correlated with the yield of exploratory behaviours [41].

- **Technology Adoption**: as for the DIME Behavioural Consequences model, it is based on the TAM approach with Intension to use (subjective) and Actual use (objective) that are the two mentioned factors for technology adoption. They are directly related with the user's perceptual TA. For technological systems, intention to use is regarded as the major subjective metric in user experience evaluation [42, 43, 44, 45]. An advantage of this metric is its relative ease of assessment. Its objective counterpart - actual system usage - is an important indicator for the extent of technology adoption. Nevertheless, researchers need to observe users over time to quantify this metric (e.g., six months of field study [46]), which can be challenging in controlled studies. According to the TPB (revised version of the TRA) [47], behavioural intention is a strong predictor of actual behaviours. Thus, "intention to use" often becomes the substitute in actual evaluations [43].

The different constructs for the Experiential side are described as follow:

- **Social Behaviour**: it represents users' behaviours and responses during social interaction and social networking related activities supported by the use of the technology at hand. This can be measured objectively, through, for example, the frequency and intensity of interactions and the graph of the users' social network in order to count the number of a user connection as previously existing or newly created. There could be metrics such as centrality coefficient and other social networking metrics.

- **Empathical Behaviour**: it represents users' behaviours and responses during social interaction and social networking related activities supported by the use of the technology at hand. This can be measured objectively, through, for example, the empathical response frequency, speed and intensity (e.g. sending a supportive message). Deciphering the type of social emotion, such as embarrassment, guilt, shame, and pride, is much more difficult; hence this could be evaluated subjectively, through, for example, the use of bipolar surveys or ethnographic observations.

- **Emotional Behaviour**: it represents users' behaviours and responses during individual as well as group activities supported by the use of the technology at hand. This can be measured objectively, through, for example, the emotional response frequency, speed and intensity (e.g. smiling when using a specific application feature). Deciphering the type of an individual emotion, such as happiness, excitement, sadness, surprise and scaring, is much more difficult; hence this could be tentatively measured by the capture of face expression and speech analysis as various tools already exist. This could be subjectively evaluated, through, for example, the use of bipolar surveys or ethnographic observation.

4. Experiment on Augmented Golf

Tele-immersion is aimed to enable users in geographically distributed sites to collaborate in real time in a shared simulated environment as if they were in the same physical room. Tele-immersion refers to a set of technologies, which allow individuals to feel as if they were present, or to give the appearance of being present somewhere else than their actual location. The feeling of presence depends very much on the users' immersive state. It requires providing the proper stimuli to users' senses in order to get the feeling of being immersed into another place. For example, Airbus's recently presented a vision, entitled "The Future by Airbus[1] - Concept Plane Cabin", that includes augmented reality applications in the cabin, such as a virtual interaction space (see Figure 6) where passengers could play golf through the immersion in a virtual golf course.

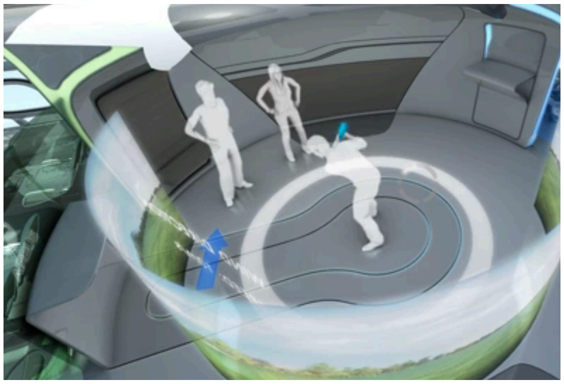

Figure 6. The Cabin interaction space featuring sport activities, Airbus.

This vision could be extended for remotely playing golf with friends that are playing on a real golf course, almost as simple as remote conference. The first experiment designed within 3D LIVE addresses the evaluation of the impact of social interaction on the feeling of presence; hence getting a better understanding on the proper stimuli to users' senses in order to increase the degree of immersion. At this stage it is important to bear in mind that people have the capacity of immersing themselves in a story while reading a book. Our brain has a huge capacity to emulate our senses, just think about dreams and nightmares.

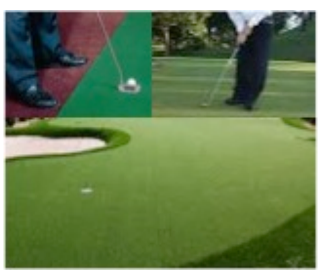

Figure 7. The "Augmented Golf Putting" experiment with a remote indoor player and outdoor player.

While designing this experiment on "Augmented Golf Putting", it was decided to use a bipolar scale survey for each of the QoE elements described in the section 3. While MOS (Mean Opinion Score) has been used for decades in the telephone industry for assessing the network quality from users' perception as a subjective measurement, it appears to be less relevant for assessing the User Experience.

Beside the Platform QoS data, demographic data and platform usage data, users have to describe how they perceived their interpersonal interactions, level of connection, degree of empathy, emotional state, the level of challenge, degree of motivation and pleasure, level of concentration, degree of immersion, and finally the level of usefulness, user-friendliness and reliability.

5. CONCLUSION

In conclusion, UX related frameworks, models and methods have emerged from different research streams (e.g. HCI[2], HCC[3], Human Factors, Ergonomics, Interaction Design), hence, are understood and described in different ways. Therefore, it does not facilitate the disambiguation among the multiple terms used for describing the different UX elements that often have some overlapping aspect and granularity inconsistencies. The current lack of comparative studies on existing UX models and elements constitutes a barrier towards a more integrative approach that could be expressed through a holistic view of UX.

Furthermore, one could be worrying about the exact meaning of "Quality of Experience" compared to the meaning of "User Experience" and eventual overlaps between the two concepts. According to Wu [16], the concept of "Quality of Service", which is composed of technical metrics (e.g. bandwidth, response time, synchronization, jitter), directly influences the QoE that allows assessing the level of the user experience including the acceptance and adoption of technology. However, the Wu's layers of QoS (network, system, application) could be more complete in including the Device layer (e.g. smartphone, tablet) as for example the display size-definition and keyboard or touch screen input will also directly impact the user experience. Kilkki [48] elaborated a framework for analyzing communications ecosystem that positions QoS between the network and application while QoE appears between the application and the user (see Figure 8).

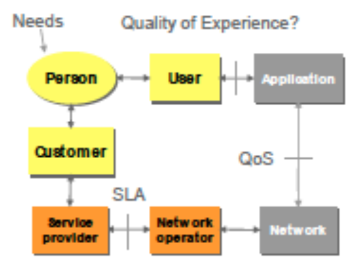

Figure 8. Kilkki's framework for analysing communications ecosystem [48].

In contrast, De Moor [49] provides a conceptual model of QoE that includes QoS as the quality of effectiveness. In this study we came to the conclusion that QoE is an approach for assessing the quality (level) of the user experience as a causal chain, making abstraction of the other contextual factors, QoS -> UX -> QoE that could be translated in QoS factors impact UX while human perception factors impact QoE. The briefly described experiment on "Augmented Golf Putting" will be used for evaluating this approach within the context of DIME and more specifically TIE.

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[1] http://videos.airbus.com/video/iLyROoafzfJ5.html

[2] http://en.wikipedia.org/wiki/Human_computer_interaction

[3] http://en.wikipedia.org/wiki/Human-centered_computing

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