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Virtual and Augmented Reality in Finance: State Visibility of Events and Risk

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1. Introduction

The recent financial crisis and its aftermath motivate our re-thinking of the role of Information and Communication Technologies (ICT) as a driver for change in global finance and a critical factor for success and sustainability. We attribute the recent financial crisis that hit the global market, causing a drastic economic slowdown and recession, to a lack of state visibility of risk, inadequate response to events, and a slow dynamic system adaptation to events. There is evidence that ICT is not yet appropriately developed to create business value and business intelligence capable of counteracting devastating events. The aim of this chapter is to assess the potential of Virtual Reality and Augmented Reality (VR / AR) technologies in supporting the dynamics of global financial systems and in addressing the grand challenges posed by unexpected events and crises. We overview, firstly, in this chapter traditional AR/VR uses. Secondly, we describe early attempts to use 3D/ VR / AR technologies in Finance. Thirdly, we consider the case study of mediating the visibility of the financial state and we explore the various dimensions of the problem. Fourthly, we assess the potential of AR / VR technologies in raising the perception of the financial state (including financial risk). We conclude the chapter with a summary and a research agenda to develop technologies capable of increasing the perception of the financial state and risk and counteracting devastating events.

2. Traditional use of VR / AR

Virtual Reality and Augmented Reality tools and technologies supply virtual environments that have key characteristics in common with our physical environment. Viewing and interacting with 3D objects is closer to reality than abstract mathematical and 2D

representations of the real world. In that respect Virtual and Augmented reality can potentially serve two objectives (Maad et al, 2001): (a) reflecting realism through a closer correspondence with real experience, and (b) extending the power of computer-based technology to better reflect "abstract" experience (interactions concerned with interpretation and manipulation of symbols that have no obvious embodiment e.g. share prices, as contrasted to interaction with physical objects). The main motivation for using VR / AR to achieve objective (a) is cost reduction (e.g. it is cheaper to navigate a virtual environment depicting a physical location such as a theatre, a road, or a market, than to be in the physical location itself), and more scope for flexible interaction (e.g. interacting with a virtual object depicting a car allows more scope for viewing it from different locations and angles). Objective (b) can be better targeted because the available metaphors embrace representations in 3D-space (c.f. visualization of the genome).
VR and AR technologies are currently widely used in the exploration of real physical objects (e.g. car, cube, molecule, etc.) or a physical location (e.g. shop, theatre, house, forest, etc..). In the course of exploration the user is immersed in the virtual scene, and can walkthrough or fly through the scene. The user's body and mind integrate with this scene. This frees the intuition, curiosity and intelligence of the user in exploring the state of the scene. In a real context, agents intervene to change the state of current objects/situations (e.g. heat acts as an agent in expanding metallic objects, a dealer acts as an agent in changing bid/ask quotes and so affects the flow of buyers and sellers). Introducing agency into a VR or an AR scene demands abstractions to distinguish user and non-user actions especially when these go beyond simple manipulation of objects by the user hand, or walking through and flying physical locations (Maad et al, 2001).

3. Uses of AR / VR in finance

This section considers three case studies of the use of 3D, VR and AR in Finance. The first case study was developed by the author at Fraunhofer Institute of Media Communication in Germany. It involves the development of a live edutainment financial content MARILYN (Chakaveh, 2005; Maad, 2003a; Maad, 2003b). MARILYN consists of a 3D virtual human avatar presenting in an entertaining, informative, and interactive way multilingual live financial data (news and tickers) taken from various international stock exchanges. The second case study is a virtual reality application in financial trading previously developed by the author at the University of Warwick in UK in collaboration with Laboratoire de Robotique de Paris (Maad et al, 2001). The third case study describes a novel application drawing expertise from two important fields of study, namely digital image processing and augmented reality. The application is developed within the context of the CYBERII project[1] (Maad et al, 2008). It features a human (the user) immersion in a virtual world of financial indicators for exploration and apprehension. This immersion aims at augmenting the user's perception of the financial market activity and at equipping him/her with concrete information for analysis and decision making. The user immersion in a virtual world of financial indicators serves in reflecting realism through a closer correspondence with real world experience, and in extending the power of computer-based technology to better reflect abstract experience.

[1] http://artis.imag.fr/Projects/Cyber-II/

A comparison is drawn to highlight an added value in the shift from the use of 3D to Virtual Reality and Augmented Reality in finance.

3.1 Use of 3D / VR in finance

This section describes MARILYN Marilyn (Multimodal Avatar Responsive Live Newscaster) a system for interactive television, where a virtual reality three-dimensional facial avatar responds to the remote control in real time, speaking to the viewer and providing the requested information (Chakaveh, 2005; Maad, 2003a; Maad, 2003b).

Marilyn informs the viewer with a click of a button on daily financial news. The focus is on the provision of choice as well as personalization of information in an entertaining manner. As well as offering live financial data from leading stock exchanges such as New York, London, Frankfurt and Tokyo, multilingual aspects of the information are also catered for.

Traditionally, financial news has been regarded as content-based and rather rigid in format. In contrast, the edutainment aspects of Marilyn can make such a program entertaining as well as informative.

MARILYN consists of a 3D virtual human avatar presenting in an entertaining, informative, and interactive way multilingual live financial data (news and tickers) taken from various international stock exchanges. The use of the 3D virtual character aims at reducing the rigidity of delivering purely structured financial content consisting solely of indicators and charts. The voice replies, facial expressions, and hands and body gestures of the virtual human avatar provide a rather entertaining and informative medium to convey financial knowledge to the target audience. Five stages are adopted in the development of this live edutainment financial content (Maad, 2003a; Maad, 2003b):

- *Stage 1* involves the development of a template for an animated virtual human avatar enriched with facial expressions, voice replies, and hand gestures. The template gives the option to choose a desired virtual human character.
- *Stage 2* involves developing several multilingual templates for live financial news content (tickers, and news) taken from various international stock exchanges.
- *Stage 3* involves establishing a bi-directional communication medium between the virtual human avatar and the financial content.
- *Stage 4* involves establishing an interactive communication medium between the animated virtual human avatar and the target audience.
- *Stage 5* involves checking the compliance of the used technology with the prevailing standards for the target media delivery platform.

The first prototype of the live edutainment financial news content, depicted in Figure 1 above, was developed for an internet platform and was called MARLYN (**M**ultimodal **A**vatar **R**esponsive **LI**ve **N**ews caster). The prototype for the Internet platform consists of:

- ***A facial animation player applet[2] that is MPEG-4 FBA[3] (facial and body animation) compatible:*** The facial animation player decodes an MPEG-4 facial animation content generated from a given source and apply the results to a face model developed using 3D face modelling tools. The MPEG-4 FBA decoding process is based on integer arithmetic and adopts the interpolation from key position method (the same as the morph target approach widely used in computer animation and the MPEG-4 Facial Animation Table (FAT) approach).

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[2] Developed by Visage Technologies (http://www.visagetechnologies.com/)

[3] ISO/IEC 14496 – MPEG-4 International Standard, Moving Picture Experts Group, www.cselt.it/mpeg

Fig. 1. MARILYN: "Multimodal Avatar Responsive Live News Caster"

- ***A facial and body animation generator tool, Fbagen[4], for dynamic generation of speech and lip sync bit stream files:*** For generating speech bit stream file, the Fbagen tool uses Microsoft SAPI[5] (Speech Application Programming Interface) as an interface for the SVOX[6] text to speech synthesiser (TTS) that uses SVOX voices. Fbagen also uses a lip sync encoder for generating the lip sync files. The lip sync file is encoded as an MPEG-4 FBA bit stream using high-level viseme parameters for lip movement encoding and viseme blend with linear interpolation for co-articulation. The Fbagen tool takes as input a text string and generates the corresponding FBA streams (.fba files) and speech files (.wav files). The generated FBA streams and speech files constitute the facial animation content that is input to the facial animation player.
- ***JAVA programs for extracting live financial contents (news and tickers) by parsing web financial sites:*** The extracted data (put in the form of a *String*) is passed as a command line argument to the Fbagen tool in order to generate the corresponding FBA streams and speech files.
- ***A Flash[7] interface for menu-like interaction with the 3D virtual character:*** The interface provides 2-dimensional navigation of various selection options of the multilingual financial content.
- ***A Flash display of the live financial news content:*** This content is basically the one extracted using the JAVA programs.
- ***A web page framing the whole work:*** This web page consists of 4 frames. These frames are for the applet, the flash interface, the flash financial content display, and the application's header respectively. This web page is preceded by an introductory web page motivating the subsequent content.

The Internet prototype of the live edutainment content is implemented in a client/server architecture. At the server-side, the financial content is extracted and the MPEG4 FBA and speech files are generated. At the client-side, the play-out out of the facial animation, the interaction, and the display of the live financial content takes place, and are framed in a web page.

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[4] http://www.cybermecha.com/Studio/ca02.pdf
[5] http://www.microsoft.com/speech/
[6] http://www.svox.com
[7] Flash is a Trademark of Macromedia.

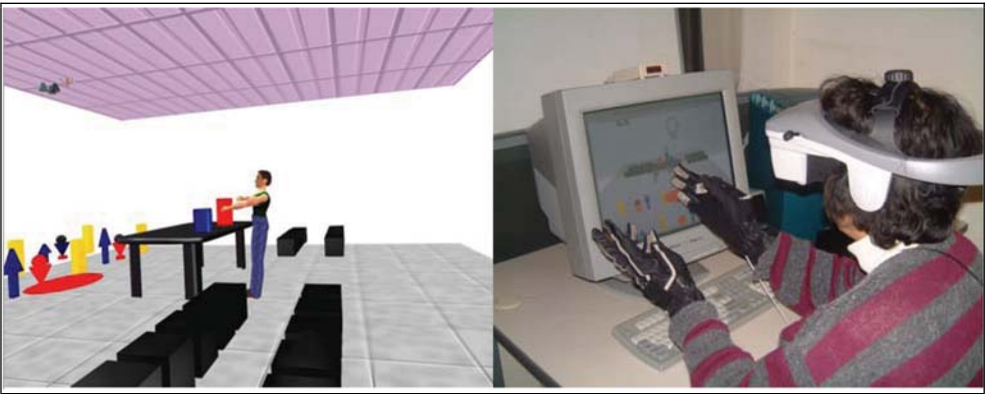
The portability of the live edutainment financial content to a mobile Personal Digital Assistant (PDA) platform involves the customisation of the user interaction interface to a mobile device style of interaction, and the in-house development of new versions of the facial animation player and the facial and body animation generator. The new design would ultimately use less system resources and is rather compatible with the uses of high quality voices produced by various text to speech synthesisers (TTS) and speech application programming interfaces (SAPI).

3.2 Use of VR in finance

Over recent years it has become increasingly obvious that text-based communication poses significant stumbling blocks to unambiguous communication. Virtual reality showed its benefit for the transfer of information and knowledge through the concept learning from the interaction with immersive 3D environment. Virtual reality and related technologies allows creating virtual environments with key characteristics that represent real world situations. The visualization and interaction with virtual objects is closer to reality than abstract mathematical and 2d representations of complex scenarios. In this respect virtual reality can potentially serve two objectives: (a) reflecting realism through a closer correspondence with real experience, and (b) extending the power of computer-based technology to better reflect "abstract" experience such as interactions concerned with interpretation and manipulation of symbols that does not have obvious embodiment.

The main motivation for using VR in financial trading is to enhance the user perception and cognition about the complexity of the financial market mechanisms and manifestations. The added value of using virtual reality in modeling financial market is its advanced visualization technique and metaphoric representation that mimic real world situations. Immersive multisensory interaction that includes vision, spatialized audio and haptic sensation provides the user with the illusion of being in real financial market. The user is confronted with nested scenarios and has to generate solutions by taking into account multi-criteria affects. He can develop various strategies in virtual environment to support decision making that reduces the risk of making wrong decision in real financial trading conditions. This approach improves learning, allows generating empirically driven decision and gaining experience from a synthetic world close to reality. Being immersed in a virtual environment the user acquires the feeling that he is interacting with real financial trading market. He interacts with the virtual agents and metaphors representing trading operators, he optimizes his actions using the procedure of trial and error. The user can define strategies, he takes actions, and perceives the consequence of his decisions with high degree of visualization that enhances his awareness about the complexity and unpredictable events that could happen in real financial market.

This section describes a virtual reality application in financial trading developed by the author at the University of Warwick in UK in collaboration with Laboratoire de Robotique de Paris (Maad et al, 2001). The virtual reality application, depicted in Figure 2 below, involves a user playing the role of a dealer who sets his/her bid/ask spread to attract buyers and sellers. The presence of the dealer in the rendered virtual reality scene is a simulated presence. As such the virtual reality simulation is fully detached from the real world. The virtual environment is represented to the user through a head mounted display. This peripheral provides the sensation of being immersed in the virtual scene. The actions of the user are communicated to the virtual environment using a 3D interaction tool: a pair of



a. The virtual financial environment b. The interaction mode

Fig. 2. The Virtual Reality simulation

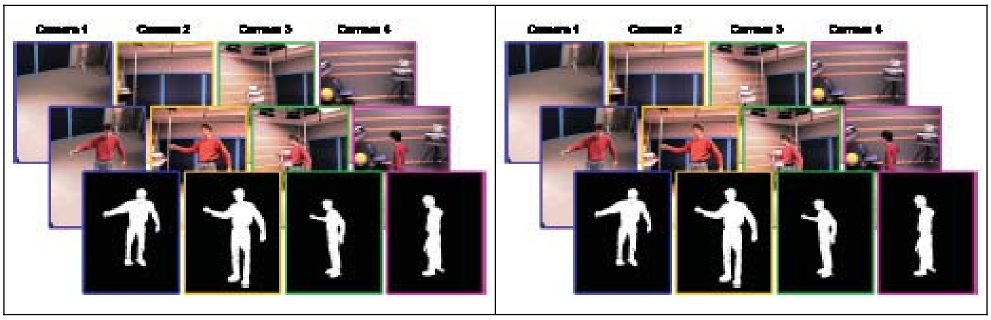


Fig. 3. CYBER II technology: image capturing (left image); image-based reconstruction (right image)

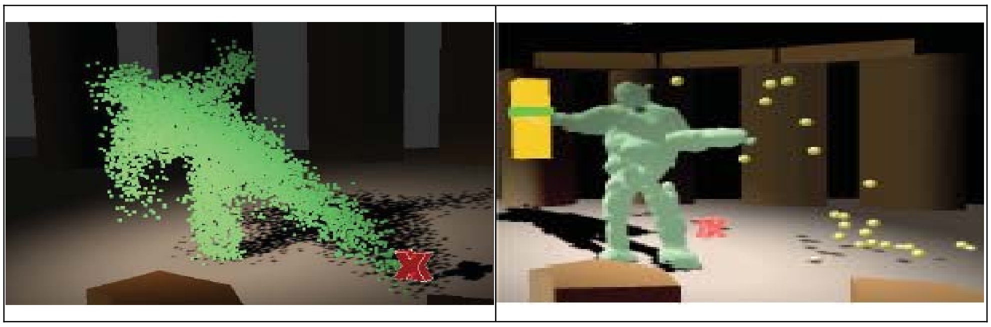


Fig. 4. CYBER II technology: Interaction with: an on/off button (left image); Interaction with a slider active region (right image)

Pinch Gloves. Figure 4 shows a screenshot of the virtual financial environment. The dealer manipulates his bid and ask prices (red and blue cylinders) to attract buyers and sellers (informed and uninformed traders).

Despite the added value of virtual reality approach in financial trading, in terms of the improved user perception of the financial market activities and of the role of the dealer in manipulating the true price of a security, the isolation of the user from the real world and the constrained interaction (the user has to wear a head mounted display and a pair of Pinch Gloves to acquire the feeling of immersion in the virtual world) makes the experience lived by the user (dealer) not sufficiently realistic (Maad et al., 2001).

3.3 Use of AR in finance

In this section we overview the CYBERII project (Hasenfratz et al 2004; Hasenfratz et al, 2003) and present the case study of the use of CYBER II technology in Finance (Maad et al, 2008).

The CYBERII project (Hasenfratz et al 2004; Hasenfratz et al, 2003) aims at simulating, in real-time, the presence of a person (e.g. a TV presenter or a teacher) in a virtual environment. Novel paradigms of interaction are proposed within the context of this project. These paradigms involve full body interaction with the virtual world in real time. This goes beyond traditional modes of interaction involving the use of mouse, remote control, pinch Gloves, or human sensor equipments.

The CYBERII project adopts a five steps technique to insert one or several humans in a virtual interaction space. It uses the notion of "Active Regions" to initiate the interaction with the virtual world. Actions are triggered upon body interaction with "Active Regions". This interaction may take the form of touching the "Active Region" and may be technically sensed using image analysis techniques that identify a body presence in the "Active Region". As described in (Hazenfratz et al., 2004; Hazenfratz et al., 2003), the CYBERII project adopts the following five steps:

- Multi-camera image acquisition, from different view points, of real moving bodies (see Figure 3 - left image).
- Reconstruction, modelling, and motion tracking of the acquired bodies and the surrounding environment (see Figure 3 - right image).
- Rendering of the reconstructed bodies and their surrounding.
- The creation of patterns of interaction in the rendered world using "Active Regions" as shown in Figure 2. Examples of "Active Regions" in a virtual interaction space include: the On/Off Button "Active Region" (see Figure 4 - left image) and the moving slider (see Figure 4 - right image).
- Data management and distributed parallel computing to meet the real time and realistic rendering constraints.

The CYBERII project targets various industries including: (1) the TV industry (e.g. virtual sets and online presentations); (2) the game industry (e.g. inserting real persons in the game world); and education and entertainment (e.g. allowing visits and presentation of remote places). The proposed novel paradigm of interaction developed within the scope of the CYBERII project, namely full body interaction with active regions, promises universal accessibility to media content. For instance, physically impaired users may find a greater convenience in full body interaction with a virtual scene instead of interaction with a mouse, a keyboard, or a remote control.

The CYBERII augmented reality financial application, depicted in Figure 5 below, involves the insertion of a user (playing the role of a financial dealer) in a virtual world, and the use of the technique of sliders "Active Regions" to enable the body interaction of the user (dealer) to set his/her bid/ask prices for attracting buyers and sellers (Maad et al, 2008). The flow of buyers and sellers is abstractly represented by synthetic objects generated in the augmented scene following the user interaction with active regions. Figure 5 shows how the technique of slider "Active Regions" can help the dealer adjust his quotes to attract buyers and sellers. The flow of buyers and sellers is represented by red balls (for sellers flow) and yellow balls (for buyers flow). This flow is trigerred through body interaction with the sliders "Active Regions". This illustrates how the CYBERII concept of full body interaction with a virtual environment and the technique of slider "Active Regions" could be used for greater engagement and unconstrained immersion in a virtual world of financial indicators. The simulation augments the real world with perceptual knowledge about bid-ask spread variation and about the flow of traders (buyers and sellers) as a result of this variation.

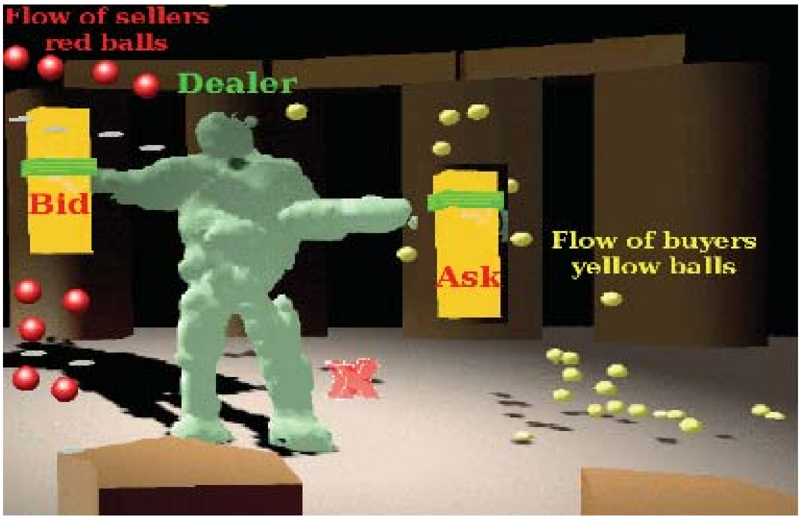


Fig. 5. The CYBERII financial application

3.4 Comparative analysis of the use of AR and VR in finance

MARILYN aims at substituting reality (use of 3D avatar instead of real human to present TV programs). The use of augmented reality instead of virtual reality aims at breaking the separation of the financial application from the real world and at augmenting its realism. Further reality augmentation to the rendered scene can be gained by adding, as a background, a synthetic depiction of the activity of the financial market. This is shown in Figure 6 below. Reality augmentation can be also gained by adding a synthesized speech that tells us about the current actions taken by the dealer (the incrusted human), the impact of the dealer's action on the flow of traders (buyers and sellers), as well as on the whole financial market activity.

Many challenges may face the use of the application 3D/AR/VR in finance. These include:

- ***The maturity of the technology:*** Earlier empirical studies conducted in (Maad, 2003a) reveals the limitation of 3D and audio technologies in meeting standards for authoring interactive television content. This is attributed to the lack of realism of the media content authored using the prevalent technologies. For instance in the CYBERII application, we

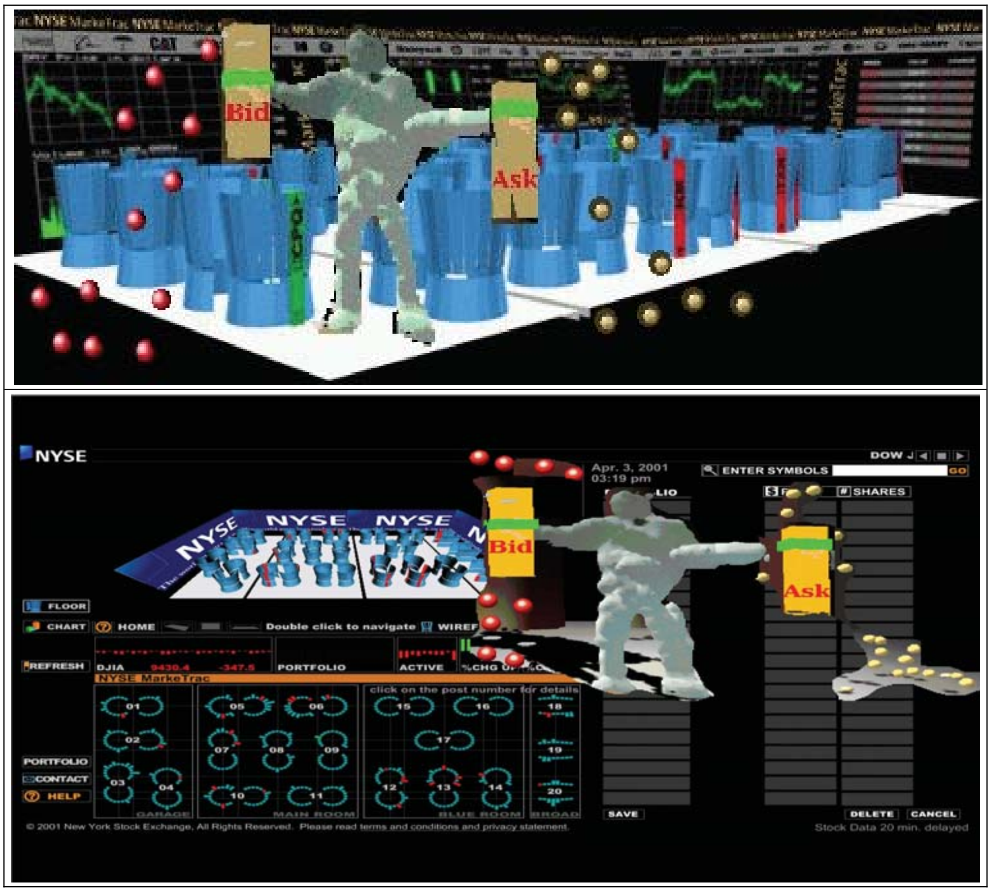


Fig. 6. CYBERII incrustation in a Virtual World of Financial indicators (illustrative example)

can see that the rendered human(s) lack realism as shown in the figures. This may have an impact on the appeal of the current technology to the financial community.

- *The choice of the medium of delivery:* Four potential medium of delivery can be considered, these include: the PC, the Internet, the interactive television (ITV), or other home/office devices. A closer look at the hardware setup of the CYBERII project, described in (Hazenfratz et al., 2004; Hazenfratz et al., 2003) as a networked set of 4 cameras, 4 PC, and one supercomputer, reveals great challenges in the portability and interoperability of the CYBERII technology.
- *Users interest:* The widespread penetration of 3D/AR/VR technologies among the financial community depends on the current demand for applications such as the one described above. If this demand ever exists then it would be limited among a few novice community who fancy new technologies.

In face of these challenges, more research work, beyond the development of the technology, need to be undertaken to justify the usability and utility of 3D/AR/ VR technologies in meeting various industries' needs.

4. Financial state visibility case study

The urgent economic problem, linked to the financial crisis, challenges current research and technological development. The scale of the fiscal crisis that undermined the credibility of the financial system motivates the consideration of "Global Financial State Visibility" as a key global challenge that validates research and technological development activities to support the engineering dynamics of automatically adaptable software services along the "global financial supply chain" (Maad et al, 2009). Financial state could be conveyed in various ways:

- perception the state of financial risk
- perception of financial events
- percent of the financial activity
- perception of the financial system and regulatory framework

Our aim is to align the prevalent thinking in terms of mediating the financial state using reports or static models to mediating the financial state using advanced visualisation and interaction technique. Key issues to consider are who will access, manipulate, and govern the financial state. Various entities (policy makers, regulators, auditors, accountants, investors, consumers, suppliers, producers, individuals) need to access /govern / adapt Financial state Visibility depending on service level agreements SLA (see Figure 7 below).

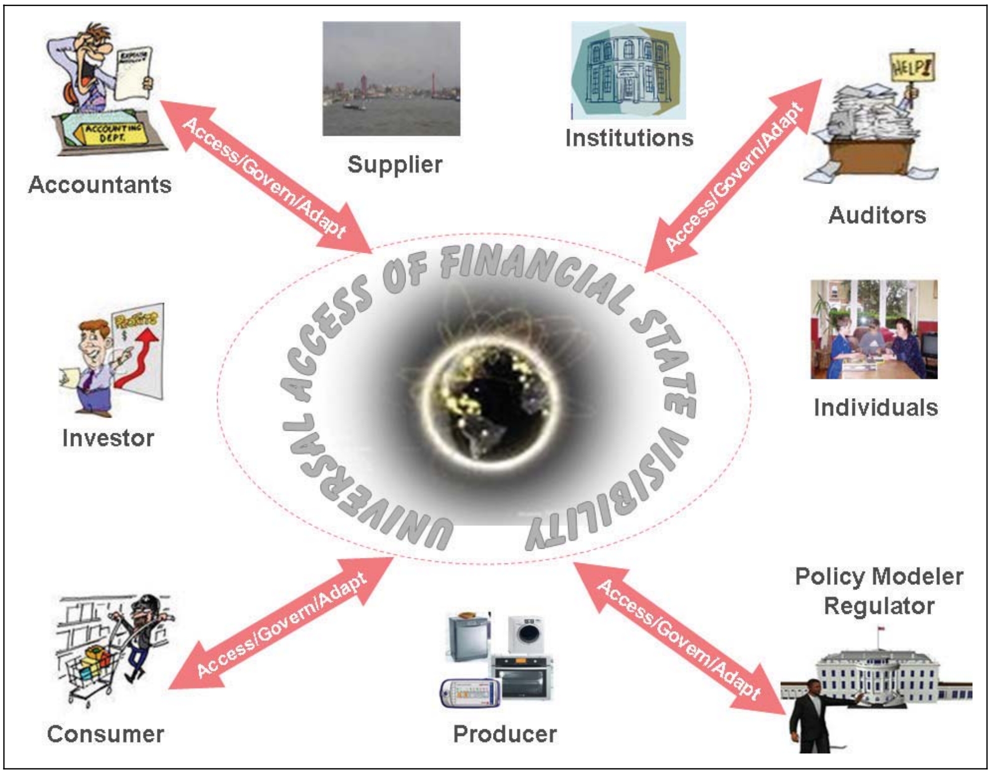


Fig. 7. Actors that need to access /govern / adapt Financial state Visibility

The Financial state visibility challenge has various dimensions:

- *Domain knowledge dimension:* this involves building the financial state knowledge base (the development of techniques to store and manipulate the semantic representation of the financial state by various stakeholders including regulators, investors, and central banks worldwide); and the visual rendering (using techniques such AR/VR) of the financial state knowledge base.
- *Converged ICT and media dimension:* this involves the development of an interoperability layer at the service infrastructure and interface levels to guarantee instant access to financial state via various converged ICT and media devices.
- *Global factors dimension:* financial state knowledge is stored and manipulated in different languages and different structures and formats. This raises geographical cultural, and accessibility technical challenges. Rendering of the financial state needs to adapt to "global context on demand".
- *Governance dimension:* There is an urgent need to support the governance of the financial state with greater perception and manipulation capability tools.

Various financial state visibility services, depicted in Figure 8 below, could be developed taking into account the above considered dimensions. These services can be grouped into various levels and categories:

<u>*Domain Levels Services:*</u>

- Domain Services: Encapsulate/wrap/Render Domain Knowledge aspect
- Technology Convergence services: Accessibility and Interoperability Services
- Global Factors Services: Encapsulate/wrap/render global factors knowledge
- Governance Services: Encapsulate /wrap/render Governance knowledge

<u>*Integration Services Exchange:*</u>

Handle exchange communication between domain level services and integrative framework services

<u>*Integrative Framework Services:*</u>

Integrate functionalities of domain level services

- Integrative Framework Services
- Integration Framework Service Exchange

<u>*Mediators services:*</u>

Mediate Integrative services to various users at various levels according to Service Governance Level Agreement

- Mediator Service Exchange
- Adaptation Service Mediators

The design and engineering of these state visibility services involves: composition, workflow, adaptation at design time and run time consideration, agency interaction, verification and validation. Key issue is the delivery of AR / VR along the chain of services workflow.

Users of the services are conceived at two levels: level 1 end users are developers of internet of things; and level 2 end users are end users of internet of things

Users at both level govern access, discovery, and manipulation of state visibility services according to Governance Service Level Agreements GSLA.

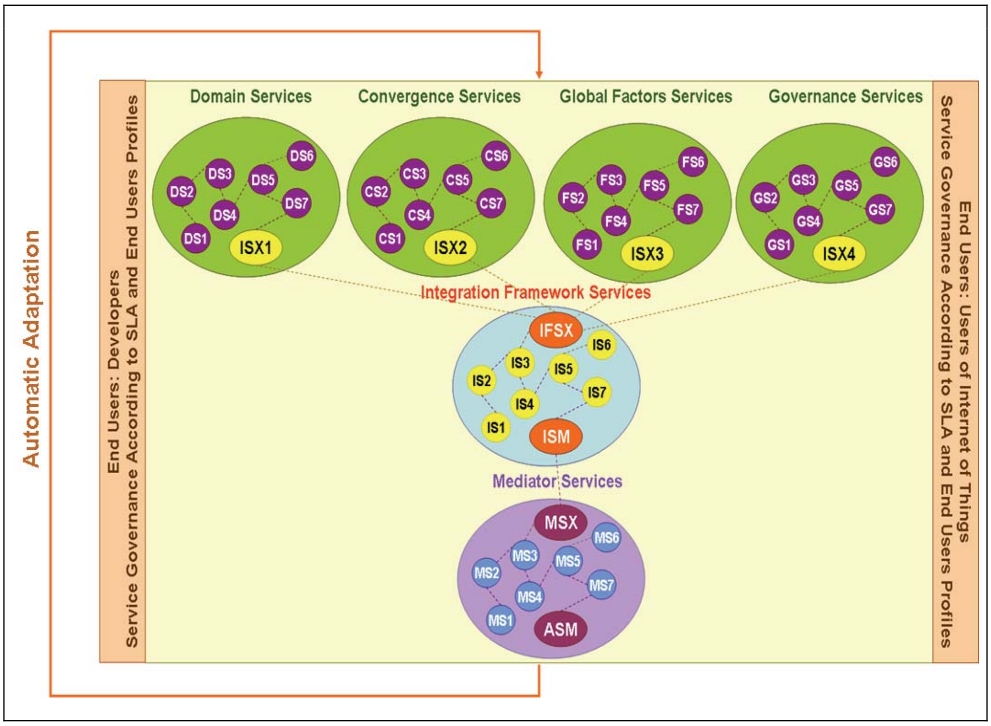


Fig. 8. financial state visibility services

5. Use of AR / VR for greater financial state visibility

This section proposes a blend of approaches to mediate financial state visibility as a service using VR / AR technologies.

The 3 applications overviewed in section 3 above highlight a limitation of existing 3D/VR / AR technologies in wide industry penetration. This is mainly attributed to portability and utility of the technology.

We suggest below service oriented software engineering and Empirical Modelling as a blend of approaches for greater portability and usability of 3D / VR/ AR technologies

5.1 Service software engineering

Given the need of massive computational power and distributed access by various actors of the financial state, 3D / VR / AR technologies can largely benefit from service oriented computing to mediate, using high end visualization, the financial state and risk to various actors.

According to (Di Nitto et al, 2009), service-oriented computing (SOC) represents one of the most challenging promises to support the development of adaptive distributed systems. Applications can open themselves to the use of services offered by third parties that can be accessed through standard, well defined interfaces. The binding between applications and the corresponding services can be extremely loose in this context, thus making it possible to

compose new services on the fly whenever a new need arises. Around this idea a number of initiatives and standards have grown up, some of them focusing on how such roles need to interact with each other, and some others on how to engineer systems based on such a model and on how to provide foundational support to their development. In particular, so-called service-oriented applications and architectures (SOAs) have captured the interest of industry, which is trying to exploit them as the reference architecture to support Business to Business B2B interaction. According to Forrester Research, the SOA service and market had grown by $U.S. 4.9 billion in 2005, and it is forecasted to have an interesting growth rate until 2010, with a compound annual growth rate of 88 percent between 2004 and 2009.
The SOC road map, figure 9 below extracted from (Di Nitto et al, 2009), separates basic service capabilities provided by a services middleware infrastructure and conventional SOA from more advanced service functionalities that are needed for dynamically composing (integrating) services. The SOC road map highlights the importance of service modeling and service-oriented engineering (i.e., service-oriented analysis, design, and development techniques and methodologies that are crucial elements for the development of meaningful services and business process specifications).

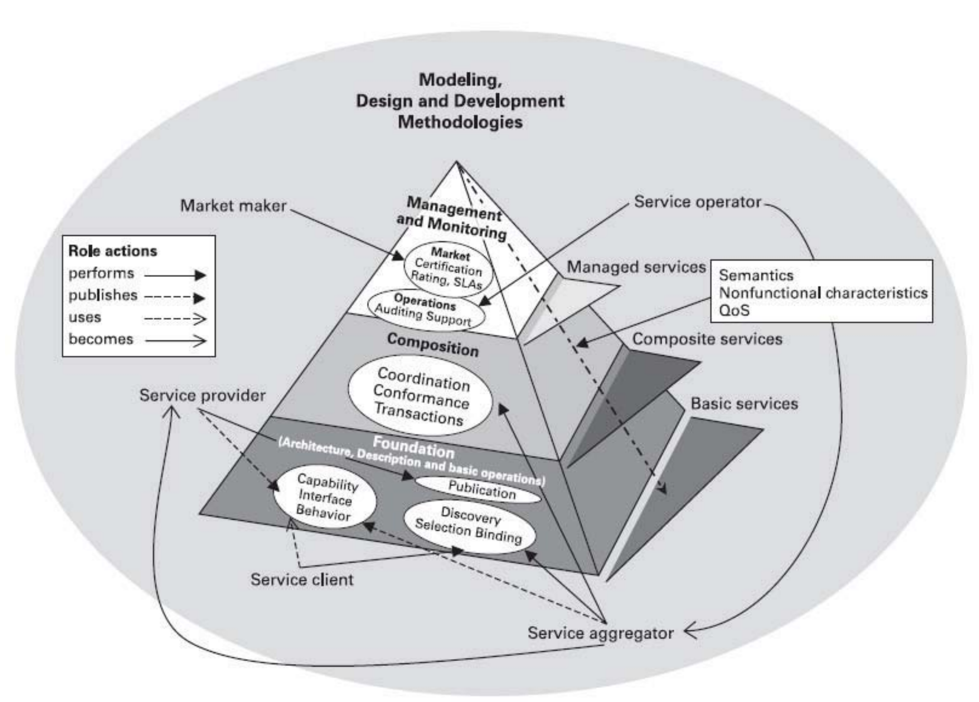
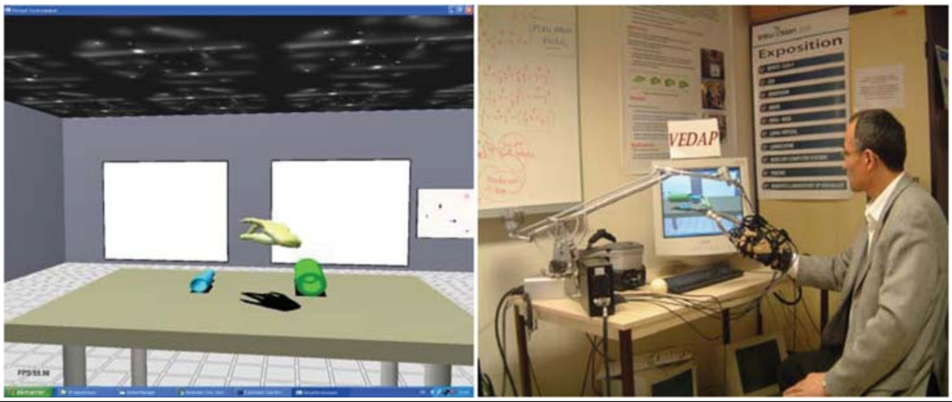


Fig. 9. the Service Oriented Computing roadmap (extracted from (Di Nitto et al, 2009)

5.2 Empirical modelling
The challenges faced by the use of 3D/ VR / AR for constructing virtual environments for finance are best revealed by drawing a comparison with its use in computer-aided assembly (Garbaya et al, 2000). This comparison reveals a difference in the objective, considerations,

approaches, and user role in constructing visually rich virtual environment for different contexts. The main objective in using 3D/ VR / AR in finance is enhanced cognition of state; in the case of virtual assembly the main objective is to minimise the need for building physical prototypes. The issues to be considered in applying 3D/ VR / AR for financial state visibility and in virtual assembly differ in nature and importance. In virtual assembly, the major concerns are proper 3D picture capturing, conversion, and adding behaviour to objects; in 3D/ VR / AR for financial state visibility, they are geometric abstraction of financial concepts, integration with financial database, and distributed interaction. The steps followed to create a virtual scene for virtual assembly and for financial state are different. A linear, preconceived, set of processes can be followed to develop a scene for virtual assembly. These can be framed in three stages: defining objects to be assembled, preparing the assembly geometry for visualisation, and adding behaviour to visualised objects. Creating a virtual scene depicting financial state is more complicated and cannot be framed adequately in a pre-conceived way. However, a broad outline can be traced to guide the construction process. This involves: identifying entities (both those that admit geometric abstraction and those that have already a well recognised geometric representation) to be included in the virtual scene; choosing an appropriate geometric representation for these entities; adding a situated behaviour and visualisation to entities; identifying the external resources (such as databases, files, data feeds, etc.) to be interfaced to the virtual scene; and framing the role of the user intervention in the simulation. Where human intervention is concerned, the user's role in the 3D/VR/AR scene is more open-ended in a financial context than in an assembly context. In a 3D/ VR / AR scene for assembly the immersion of the user is very important: the user can manipulate virtual objects with his hands. The user's hands, guided by the user's brain, interact directly with virtual objects. This makes virtual reality approach appropriate for modelling the process of assembly task planning (see Figure 10).



a. Virtual assembly environment	b. Assembly planning and operation with haptic interface

Fig. 10. Example of VR modelling for areas such as assembly planning

Construing financial phenomena is a function performed by the human brain. The mental model of the designer can be abstracted in a static diagram, a 2D computer artefact, or a VR / AR scene. Geometric objects in the virtual scene might admit no counterpart in the real world - they are purely geometric metaphors. This makes a virtual scene just one of several possible representations. It also motivates a prior situated analysis exploring possible construals pertaining to the social context. The above comparison highlights the need to support 3D/ VR / AR technologies with principles and techniques to analyse and construe social contexts and to adopt appropriate visualisations for abstract entities (such as financial indicators) that have no real geometric counterpart. Current technologies for Empirical Modelling (Beynon, 1999) can help in construing financial situations and in representing state and the analysis of agency in state change, whilst 3D / VR / AR technologies offer enhanced visualisation and scope for user immersion and experience of state.

6. Conclusion

This chapter reflected on the potential of Virtual Reality and Augmented Reality (VR / AR) technologies in supporting the dynamics of global financial systems and in addressing the grand challenges posed by unexpected events and crisis. The chapter briefly overviewed traditional VR/AR uses and described three early attempts to use 3D/ VR / AR technologies in Finance. In light of the recent financial crisis, there is a potential added valued in harnessing the use of VR/AR technologies to convey a greater visibility of the financial state (including visibility of financial risk). Various dimensions of the problem are considered. The chapter suggested a blend of service oriented computing SOC and empirical modelling technologies to support the use of VR / AR technologies in raising the perception of financial state and risk.

There is a very significant distinction between VR modelling for areas such as assembly planning as represented in papers such as (Garbaya et al, 2000), and its application for greater visibility of the financial state and risk. Whilst we can reasonably speak of "using VR to model the reality of the process of assembly planning", the reality of the financial state is an altogether more elusive concept. Where manufacturing assembly deals with objects and actions whose objectivity and real-world authenticity is uncontroversial, financial state visibility is a prime example of an activity in which the impact of technology upon human cognition is prominent, and character of its agencies and observables is accordingly hard to capture in objective terms. Empirical Modelling supplies an appropriate framework within which to address the ontological issues raised by such applications of VR / AR (Beynon, 1999).

This chapter points to the following conclusions:

- 3D/ VR/ AR technologies can help in exploring a particular state in a social context.
- The pre-construction phase of the virtual world can benefit greatly from concepts drawn from the Empirical Modelling literature such as modelling state, state change, and the initiators of state change.
- 3D/ VR / AR technologies needs to be better adapted for the representation of multiple agents acting to change the state and corresponding visualisation.
- The successful application of 3D / VR /AR technologies in modelling social and data intensive environment relies upon integrating these technologies with other programming paradigms and architectures such as service oriented computing and architecture (SOC and SOA).

Future research agenda involves the development of quantitative and qualitative metrics to assess the potential benefits of 3D / VR / AR in modelling a state in a social context. Two dimensions are appropriate: the visibility and the viscosity.

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