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Extending Aural and Music Interfaces to Mobile Device Interaction Design Architectures

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ABSTRACT
This chapter analyzes the unique problems posed by the use of computers by producers and performers of music as far as Human Computer Interaction (HCI) principles, methodologies and directives are concerned. In specific it focuses on interfaces that are built on mobile devices or similar medical equipment. HCI predicates involved in the workflow of aural interaction with computer devices are presented, starting from the abstract part of neurotologic interaction, then coping with usability issues of the Graphical User Interfaces (GUIs) implemented for musical scripting and concluding to a synthesis stage which produces digitized sounds that improve or supersede prototypal analog audio signals. The evaluation of HCI elements for Computer Music under the prism of usability, including hearing or ophthalmic aids, aims at the development of new communication tools, new symbolic languages and finally better mobile user interfaces.
Keywords-*Aural Communication, Computer Interfaces, Music Perception*

I. INTRODUCTION

Recent technological advances in the fields of mobile, wearable and implanted devices challenge for increasing demands on the quality of the user interface and offer the potential for further progress on the functionality of aural communication devices. Under this prism, Human Computer Interaction (HCI) becomes more central to the design and development of augmented reality Computer Musicsystems, investigating functionality that did not previously exist for the user or functionality that was not virtually usable.Vertigo. Center, Behind the Ear (BTE) Tube Fitting hearing aid. Right, transplanted paraphernalia - Cochlear’s Nucleus Freedom™ cochlear implant.

Although the notion for a wearable device that integrates advanced mobility characteristics is getting more and more endorsement within the wide public, the notion of transplantable devices is rather new even to the techno community (Fig. 1).

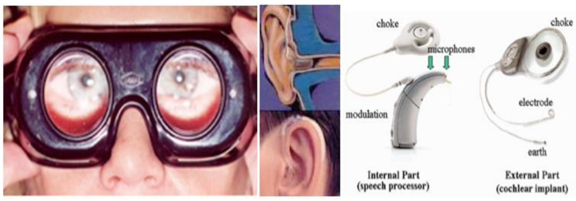

Fig. 1 Sequences of evolving species for wearable devices used for ENT diagnostic or therapeutic facilities. Left, Frenzel goggles that detect positional vertigo. Center, Behind the Ear (BTE) Tube Fitting hearing aid. Right, transplanted paraphernalia - Cochlear’s Nucleus Freedom™ cochlear implant.

It would be commonplace to note that in today’s thriving society, there is hardly any form of transaction either in communications terms (i.e. mobile telephoning, SMSing, remote videoconferencing) or social engineering (i.e. participation in social or professional networks, administration, voting, shopping, teaching and learning) that is done without ICT. The new concept that emerges besides e-business, e-commerce, e-banking, e learning, e-registration, etc., is e-music. Already, music file formats allow sound to be streamed en-masse over the network at different speeds, or to be prolifically delivered via social networks and large capacity memory sticks.

Fig. 2 Wearable and transplanted device Interfaces. Left, Google Glasses®. Center, Apple's iWatch™ . Right, a cochlear implant's choke and speech processor, as seen from outside the skull, camouflaged in the color of the hair and skin.

When omnipotent mobile or wearable devices are encountered, music as an audiovisual derivative penetrates nearly every day aspects of our interaction activity (Fig. 2), and there is an even further increase in availability by a factor of 10[1].

Although the leader in mass technology penetration was desktop computing for more than a generation, neither its *metaphor* nor its *paradigm*[2] seemed to pander more than 1.5 billion broadband installations right now. To make things worse, its marketing seems to be shivering and the offered services are less appealing for the everyday user. On the contrary, mobile computing and mobile communications are awe-inspiring the new generation and provide technological substrates for global integration and deliverance.

Three concepts need initially to be deciphered in order to approach the issue of mobile device penetration: innovation, service emancipation, and co-creation [3].

- *Innovation* does not only tamper advanced gadgets in terms of user manipulation; it also introduces the notion of new tasks via new devices, especially the *wearable* and *transplanted* ones (Figs. 1, 2). Prolonged battery life, endurance in hard treatment and affordability seem to be the driving forces for ubiquitous penetration.
- *Service emancipation* engulfs a variety of publicly widespread iterations not only between peers but also among key-role players, as is the case with the public sector or the banking sector. These services have helped users reduce the cost of various on-line transactions, primarily by re-allocating their availability “on the fly” and allowing them to exhort their core competencies. For instance, a businessman while on travel may alter his airplane schedule using his smartphone, while being in a congested air terminal and without having to access a desktop computer, or bothering his travelling assistant. After all, both these two commodities are diminishing in actual presentation. A major accomplishment of service emancipation has been the alteration of the unified perspective for state of the art Web services (i.e. what we call the Web 2.0 paradigm - see O'Reilly [4] and Cormode & Krishnamurthy [5]) to the foundation of *Demand-Driven Web Services* (DDWS), i.e. the Web 3.0 paradigm, and its technology enabler, HTML 5.
- *Co-creation* focuses on the massive creation of context. By motivating the users of a wide spread system, like Facebook or YouTube, one may achieve unparalleled streaming of data and information. The basic technology enabler lies within the ability to readily record in audio files, pictures and video streams social happenings of paramount importance for depicting in nearly real time daily social activity (Fig. 3). Although in the context of classic economical terminology the interplay is rationed between “customers” and “consumers”, in innovative environments the entities involved in such interaction are merely characterized as “users” or “peers”.

Fig. 3 Big multimedia data input devices, small in size, but really potent symbols for massive interchange.

Within this context of inner core paraphernalia and direct manipulation services, HCI bursts into an esoteric world super ceding command languages, or even further programming languages, giving room to accommodate advanced intellectual interaction. Since aural communication and especially music are in many aspects very rich and mature communicating media involving even bodily performance of some sort, and predominantly producing identity information, this chapter analyzes the unique problems posed by the use of mobile and transplanted devices when people interact with music. It presents the HCI predicates [6] involved in the chain of aural communication, commencing from the abstract part of symbolic representation and understanding. Actually, aural communication is not achieved only by recognizing the sounds we hear, but it is enhanced by lip-reading, gestures and in the case of music, by a combination of movements that meaningfully accompany the acts on stage.

Graphical User Interface (aka GUI) is called in Information Technology the super set of graphic elements, which is presented in the screen of certain digital appliances (e.g. PCs); these elements are used for the interaction of the user with this appliance.

GUIs provide users with highly symbolic graphic elements, clues and “other” tools in order to efficiently execute certain desirable operations. For this reason they accept an entry from the user via the device’s input channel and react proportionally to the incidents or transactions caused by the triggering mechanism of an appliance as is the keyboard, mouse or lightpen, to mention a few.

Most contemporary programs and operating environments for smart devices provide their users with some sort of GUI interoperability, since this kind of interaction suits enough the human experience and nature. Well-designed graphic elements establish beautiful, functional and effective work environments. Prior to this, the rule of thumb was for microcomputers and other electronic device paraphernalia, that interaction was cumbersome, non-transparent and dependent on the sui-generis "interface" each producer provided.

On the contrary, a GUI uses a combination of technologies and appliances in order to provide a platform that "hides" the hardware particularities that each device may have by providing a sustainable universality that corresponds to a visual manner for communication and interaction. So, we are leading to an era where "every 'clever' device" will have some kind of a globally accepted GUI, and "every device" includes apart from computers and smartphones cameras, projectors, TVs, car displays, elevators, bus displays, traffic control displays and many others from the set of "Internet of Things" devices.

This approach facilitates the user who needs not a profound knowledge for command languages to provide instruction for a computer or any kind of processor based appliance. The most common combination of these elements in GUIs is the WIMP (Window, Image, Menu, Pointing device) set. WIMP has been around for quite a while, and it seems that we cannot rid of it easily [6]. On the contrary, it has aspirations to be renown in history as the synonym for Personal Computing!

The WIMP type of interaction employs a natural appliance or input device to control the position of a cursor over the output device - in most cases that being the screen or an array of screens, projectors, and streaming media devices. A windows manager then checks the cursor co-ordinates and presents the reaction of the computing device as information organized in windows signified with "icons". The available commands are worked out as possible choices taxonomically grouped together as rudimentary menu elements, most of the times leading to nested menus until the appropriate interaction is epitomized. The windows manager is the GUI administrator that facilitates interactions between applications, the OS that runs the windows manager, and the file system. The windowing system is also responsible for handling a plethora of peripheral devices like cameras, sound devices, video cards and streaming devices, robot devices, scanners, 3D scanners, printers, 3D printers, Bluetooth and WiFi communication systems and so on, by providing a minimal operability via a cursor driven WIMP GUI. Therefore, the role of window managers is exhorted to handling with *realism* appliances and equipment with advanced Artificial Intelligence characteristics, so that justifiably the never aging desktop metaphor remains the undisputable leader in computer automation.

When multitouch devices appeared with advanced multi modality characteristics, engulfing sensors not present thus far in conventional computing devices (gyroscopes, accelerometers, compass navigators, tagging devices, GIS positioning capabilities, thermic and illuminance sensors,...) there was a tenacious expectation that a new sweeping metaphor would soon evolve, drifting Human Computer Interaction to spheres beyond perceptible expectations (see for example [7],[8],[9]). What went wrong?

II. THE EVOLUTION OF SPECIES: HUMAN COMPUTER INTERACTION AND HUMAN MACHINE INTERACTION CONVERGENCE

In order to give a sustainable answer to the functionally impenetrable amorphism of the new metaphor to come, we need to get things from the beginning.

2.1 Humble beginnings and development: the PARC user interface (WIMP)

The precursor of GUIs was invented in the Stanford Research Institute, then led by Douglas Engelbart. They promoted the use of hyperlinks, based then on text promulgated screens emancipating navigation for an online system by using a mouse. The notion of hyperlinking software elements was further developed, and not surprisingly was extended in graphics environments by researchers in Xerox PARC, California. The first computer that crossed the Rubicon and developed a GUI guided OS was the Xerox Alto computer. More or less, although Alto never gained business momentum or market recognition, general uses GUIs promulgate its intuition. Simultaneously, in 1983 Ivan Sutherland developed a system based on a photosensitive indicator that was named Sketchpad™. The lightpenen we all use today for drawing interactively or signing electronic documents trails its progenitor there [6].

The PARC interface comprised a set of graphic elements as windows, menus, radio buttons, check boxes, labels, input lines, scrolling bars and bitmapped icons. Apart form the omnipresent keyboard, a pointing device was needed, ranging indecisively between pen form equipment and a mouse. Ever since, although most of the equipment of that time has disappeared in oblivion, four elements instituted the heritage of our basic I/O devices: the keyboard, the mouse, the pen form pointing device, and the WIMP touch and feel [2].

The first computers to incorporate WIMP interfaces have already placed themselves well into the history of computing: the Xerox 8010 Star Information System in 1981, followed in 1983 by Apple Lisa. Lisa was the first computer to enhance WIMP with the menu bar, since then present in every Mac, and not only. And at last, in 1984 the first viably marketed WIMP computer, the Apple Macintosh 128K, and then the Atari ST and Commodore Amiga in 1985.

Although most readers may identify themselves familiar with computer systems like MS Windows, Mac Os' and even X Windows environment for accomplished '80s UNIX workstations, some sense that the advanced capabilities of the newbies, namely Symbian, BlackBerry OS, iPod, Android and iOS would not have blossomed had they not refined the astounding multimedia capabilities of Amiga and Atari computers, especially in their ride during the '90s (Fig. 4).

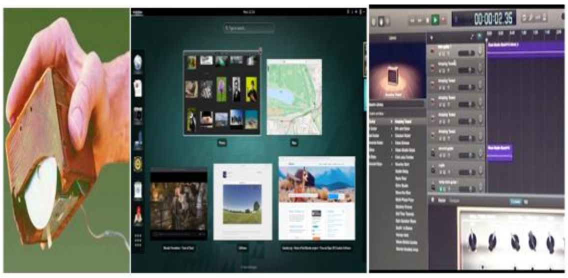

Fig. 4 Legendary minutes from the WIMP evolution: Left, the first mouse. Center, an intelligent GUI, Linux KDE. Right, a "music processor" module, capable of interconnecting directly music instruments.

Apple and IBM took advantage of many Xerox ideas lancing products and specifications that sheltered what was called the Common User Access environment. Products like Microsoft's Windows Manager, IBM's OS/2 Presentation Manager and Unix Motif™ shaped a common denominator for GUIs, the very same way Common Music Notation (aka CMN) gives a unified access for expressing musicality.

Within a generation's span many variants of these OS thrived more or less, burgeoning what is the *desktop* metaphor of our contemporary GUIs, omnipresent in PCs, laptops, netbooks, mobile devices, and more or less on today's heat, the smartphone [2].

2.2 Designing GUIs: the notion for Metaphor and Paradigm

The optical element composition alongside to the timely response to a bunch of actions trying to effectively use computer applications is the nutshell of HCI. The form, shape and good looks protract a mannerism for visually designing "widgets", i.e. elements that respond to users' transactions in a way that builds up the zenith for GUI usability: satisfaction. In technical terms satisfaction could be transliterated to the acronym WYSIWYG, which needs no further illumination for the HCI community.

Apart from their differences, widgets over diverse desktop metaphor environments promote the notion for a model-view-controller, which makes GUI programming much easier. Indeed, today's issue for programming smartphones manifests this exactly shortcoming, but the development of model-view-controllers is beyond the focus of this paper.

However, the quiver of mobile device interfaces is inherently attached to new tasks like pamphlets, "chalkboards", flipcards, slides, and of course, text, images, audio, video and animation that existed in excess within the PC world.

How do we cope with these entire interface extensions [10] that have to come as primary key players in our mobile device world?

By moving into 3 axes, in three steps:

Step 1: By defining what is *metaphor* and what is *paradigm* for mobile device interfaces.

Step 2: By reverse engineering the route from computer music interfaces to mobile device interfaces. It is exactly the roadmap from iPod to the trendy iPhone, to epitomize it in business model terms.

3. By describing how notions like "thematic parks", "cultural journeys" and "mashups" have found in smartphones and mobile device "cloud" networks their home, making this Odyssey the most successful business model of our times, both in terms of monetary input and technology emancipation.

III. THE SIMULATING PARADIGM STATUS FOR COMPUTER MUSIC INTERFACES

The use of Computer Music interfaces aims at producing melodic pieces. The instrument used in this case is a computer program, perhaps in conjunction with a keyboard hardware interface communicating via the MIDI-IN and OUT ports. Producing melodic lines is a matter of inspiration and not an arbitrary or disciplined procedure. In terms of Human Computer Interaction it means that the computer program used must have **functionality** and **usability** features that enable the user to record in symbolic form the music he has conceived. Usually, five criteria are used in order to evaluate the usability of an interface according to the ISO/DIS 9241-11 directive [6]:

a) Learnability for the use of the new system. Five principles that affect learnability are: predictability, synthesizability, familiarity, generalizability and consistency.
b) Effectiveness, i.e. the extent to which the intended goals of musical synthesis and composition are achieved. The effectiveness with which users employ a product to carry out a task is defined as a function of two components, the quantity of the task attempted by the users, and the quality of the goals they achieve.
   Effectiveness |= *f*(quantity, quality)
c) Efficiency, when used by experienced and trained users, i.e. the amount of resources that have to be expended to achieve the intended goals. This criterion is more procedural than quantitative in Computer Music. In engineering, the term "efficiency" is uncontentiously understood as the ratio of useful energy output to energy input.
d) Satisfaction, in the sense of the extent to which the user finds the use of the product acceptable and desirable.
e) Capability to use the system from users not familiar with its musical categories and predicates after a long time.

In order to evaluate the performance of Computer Music systems on alternate musical interfaces a heuristic evaluation will be performed. According to Nielsen and Mack [11] heuristic evaluation is a usability engineering method for finding the usability problems in a user interface design so that they can be attended to as part of an iterative design process. Heuristic evaluation involves having a small set of evaluators, experts in their field, examining the interface and judging its compliance with recognized usability principles (the "heuristics"). For each category of musical interface products, evaluation takes place according to the previously mentioned criteria.

At this point, the epitome of the usability computer music interfaces demonstrate will be presented:

❖Axis 1: The playing music metaphor and paradigm

As previously stated, the metaphor for computing equipment and mobile devices is well rooted into what is comprehensively called desktop metaphor, still being more or less dominant and irreplaceable. However, the paradigm for "playing" music, with what ever it means in terms of performing music, composing music or writing music, will be presented here.

Recall, that Paradigm's etymology roots into Greek παράδειγμα (paradeigma), meaning in practice a "pattern, example, sample"[10] from the verb παραδείκνυμι (paradeiknumi), meaning "exhibit, represent, expose"[12].

For example, in an effort for more natural interaction with the Computer Music systems, we need support for input devices with higher control bandwidth and dimensionality than the mouse that may lead to a faster, more natural and more fluid style of interaction for certain tasks [7]. There is also need to integrate new kinds of keyboards and a broader range of physical gestures and non-human control sources. Several works are related to new gesture input devices [9], [13].

Many musicians find the interface (mouse, computer keyboard and/or synthesiser keyboard) less natural than the traditional pencil and manuscript, so alternatives are an active area of research. Although not globally used, pen-based systems for data-entry are rapidly developing, driven by their popularity with users for accomplishing specific tasks. As a consequence, pen-based systems for music tasks are designed [14]. A set of gestures for pen entry of music was reported since 1996.

Most electronic music controllers that have been created are based on existing acoustic instruments, such as the piano keyboard. Such electronic controllers have the obvious advantage of being used relatively easily by "traditionally" trained musicians. However, there is an emergence of whole new types of controllers and new ways of performing music [15].

Indeed, that was the situation and the expectations before the new paradigm emerged, that of mobile computing. How things evolved will be illustrated with some indicative examples.

Playing a guitar:

Usually performed with extensive finger work on the frets with left hand and with a pick on the right hand (Fig. 5 left and center), it is obviously not reproducible in terms of classic computing. Neither the pointing device, whether mouse or lightpen, or the output device, the screen, can sustain such a multitouch simultaneous action. Therefore, the solution came only when tablets rather (and not that much smartphones) appeared in the central screen; see Fig. 5, right.

Fig. 5 Let, a performer playing his guitar. Centre, working the chords with a pick. Right, multitouch simulation for playing an electric guitar with iPad in a "split" display style.

Additionally, playing the guitar with the computer meant that the screen should always be in front of the musician, where as a tablet simulates more easily the playing style we assign to performing guitarists.

Playing the keyboard:

The use of a piano, or better say, a piano like keyboard, gives the musician the advantage of handily reproducing the melody in terms of scale assimilation. Indeed, no other instrument has been synonymous to sheet music reproduction than the piano. It has been demonstrated in the previous paragraph how one can play more or less the guitar with our computing device, either classic or mobile. But, how can a musician play a flute? It is obvious, thus far, that only by using it's semantic representation in music terms, i.e. by the piano roll or by the notes of the melody.

Playing the piano with classical computing simulations was difficult basically due to its inability to accept multi touch input, where the piano has been notorious for its two hand performing style (see Fig. 6).Even further, the piano had an inherent weakness in producing scales other than the ones used in Western music. It was well known in the music community that styles or rhythms other than major or minor ones used in Common Music Notation were not easily reproduced in piano roll environments. Not until recently.

Virtual instruments, like the variPiano™, demonstrate how multitouch mobile devices for starters, can overcome limitations in scales, or the number of accents and alterations considered within the intervals of given scales.

An inherent shortcoming of piano-roll keyboard configurations seems to have been overcome for the first time in both visualizing and performing terms (see variPiano in Politis et al. [16]).

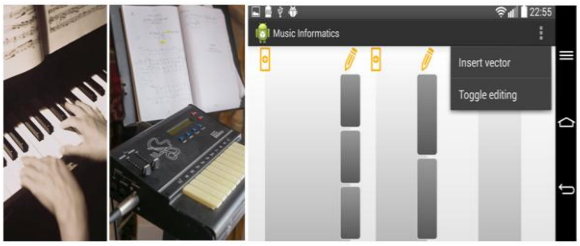

Fig. 6 What we can achieve playing a piano roll. Left, reproduce a melody written in CMN. Center, assist chanting by reproducing the "*ison"* using a piano like instrument, for Middle East ecclesiastical melodies. Right, the variPiano™ for Android, capable for multitouch reproduction of non-tempered scales with more than one alterations for its semitones.

Composing music and extending MIDI:

An editor is for composing music what is MS Word© or a similar processing package for producing documents. However, writing music is not a mainstream activity that would promulgate music processors. What make editors indispensable, is their ability to reproduce any form of music hearing, provided that it is written in CMN standards.

The music semantics are inserted either with the mouse, or for skilled professionals, by taking advantage the MIDI's ability to adhere keyboards with software packages.

In the early stages of microcomputer evolution, various protocols had been developed in order to achieve inter-connection between computers and instruments. The milestone of Computer Music proved however to be the MIDI specification. MIDI, the Musical Instrument Digital Interface, is a protocol, which specifies both a hardware interface and, simultaneously, a low level programming language for passing musically meaningful messages. It was established in 1983 in response to the increasing sophistication, and corresponding complexity, of commercial electronic instruments, especially synthesizers. Therefore, MIDI is a protocol specifying how electronic musical instruments may be controlled remotely. In brief, MIDI is a very successful and inexpensive protocol that has reshaped the Computer Music landscape.

However, it cannot overcome easily its representation limitations, especially on alternative music notations, as it has been clearly noted at least a decade ago [17].

In Fig. 7 can be seen the evolution of the MIDI-keyboard input mechanism. On the left is depicted a classic CMN editor. On the middle can be seen how apart from the computer keyboard a music keyboard can be utilized to insert music evens by playing music. It is important to note that this process is multidimensional, i.e. it can serve as input

Fig. 7 Left , FreewareBox' s Music Composer software, a fully equipped package for CMN staff based editing. Center, a writing keyboard and a music keyboard used as an input device for semantic music creation. Right, an iPad software module that enables music writing by drag-n-drop and multitouch piano roll, eliminating completely the need for a standard keyboard.

but also the synthesizer keyboard can reproduce the hearing, alone or in conjunction with the computer sound system. On the right of Fig. 8 is depicted the unifying method adopted by mobile devices. They incorporate a multitouch keyboard roll on the bottom, while a classic editor is incorporated in the upper part of the screen. The paradigm for picking up a note and placing it on the desired position within the staff roll is characteristic for both worlds.

Fig. 8 Left, today's classic, the omni present portable recording studio. Center, acououmetric interfaces used by a clinician in an ENT Department's studio. Right, NanoStudio for iOS, a system with minimalistic features but high throughput for musical streaming within the "cloud" transferring the functionality of studios to mobile devices.

❖Axis 2: The production and distribution model for mobile devices

As previously mentioned, the vast volume of music data available online motivates users not only to participate in media networks, but also gives the opportunity to some of them to become producers for multimedia content distribution [18].

In strict terms, music production and distribution is always better accomplished when using workstations or laptops with ample computing power and big screens (Fig. 8). However, the agility that characterizes mobile devices blends on they very characteristic for intimacy, i.e. the ability to be present when the event takes place. Software for music production on a smartphone or a tablet serves exactly this characteristic, which it promotes a rather underdeveloped version, i.e. a mini studio version of what would be needed to fully process audiovisual recordings.

Some applications for mobile devices are transferred from the sphere of personal computing, and try to maintain the "touch and feel" of the initial version, to which the vast majority of their users is accustomed to. Others, new comers in the field, incorporate newly designed interfaces which need not comply with a previously biased clientele in HCI terms.

As a whole, either originating from a desktop version or being entirely new concepts, production systems to

a. take advantage of mobile devices' integrated interfaces that offer faster and better audiovisual recordings under harsh situations,
b. promote the principle of an easy-to-use, "cozy" interface that proves to be productive in most cases,
c. offer prompt access to music networks, usually dispersed within the cloud, giving their users the advantage of value-added-potential, the privilege to be first to post audiovisual depiction of events within a global audience.

❖Axis 3: Participating in thematic worlds, "cloud" services and mashups

As previously mentioned, mobile devices attempt to overleap the narrow potential of the MIDI-like interconnections [17]. A first attempt is made by wiring mobile devices with a plethora of other electronic tools and gadgets that offer completion of task in a pervasive manner.

Again, the motto is: omnipresence over absolute performance. Indeed, in Fig. 9 are presented devices that may not perform outstandingly good, over studio standard equipment, but demonstrate the ability to transfer DJing capabilities to places previously unreachable, with limited conveyance.

Fig. 9 Exhibiting multipolar connections for DJing performances: Left, the Tractor software wired with a stereo Hi-Fi system. Right, a wide spectrum of WiFi and Bluetooth devices, ranging from music reproduction devices, TVs, and smartphones up to other hearing paraphernalia, interconnected at the 2.4 GHz communication band with cochlear implants.

Could, under certain provisions of course, the tasks accomplished by the equipment on the left and center of Fig. 9 completed successfully by mobile devices, like the one seen on the right of Fig. 9? Indeed, mobile interfaces have the great advantage that although they do not have yet the same level of diagnostic accuracy, they can be readily used at the patient's bed or residence, without burdening him and his custody with the hardship of transferring him to the nearest diagnostic facility.

Additionally, this sort of equipment bears an unlimited in terms of space and time access to the Internet. As a result, multimedia content that is of similar origin may be combined. For instance, a mobile device that is used for diagnostic reasons in medicine may have a sound bank of related hearings to the disease that has to be identified, facilitating the examination of symptoms. The same time, it records new events, which can be uploaded to a medical databank. All this material that is constantly downloaded forms a complex organization that promotes thematic worlds, with unprecedented depth. Moreover, the feedback that listening provides to such happenings, is again multimedia content that enriches with its uploads even further the mashup labyrinth.

Apart from the cloud of diagnostic tools, the overall music cloud scene in global dimensions leads to enormous modules that deliver an unprecedented number of high-quality hearings, and not only. Although YouTube is not by definition a site for music distribution, it can be considered as the leader in digital libraries, since it contains a huge volume of music clips online, which is enriched every day by its users. Thus, it is not accidental that YouTube is the primary source for music reference in the digital age [19]. Since all the content is online (and not stored in hard disks) and accessible by everyone, there are a lot of capabilities for music management, commenting and multimodal user participation.

For example, the application of gyroscopes within a mobile device propels Geolocation services. In this case, location-based social media offer APIs that have been well incorporated within the social sphere. Along with services like Twitter and Facebook, they provide location of persons and navigation over social gatherings, as are public music concerts. So, enhanced social media “clouds” develop from asking “how do you do” to “what do you do and where are you”.

Although not directly linked with mobile devices, the concept of the “Virtual Music Environment (VME)” emerges as a generalization of a virtual music instruments, in which the virtual world itself acts as a source of multimodal (e.g. visual, audio, haptic) feedback, and at the same time, a place of interaction. Naturally, the two important issues in designing a VME are: the display content and the control interface. These two issues are in fact inter-related as music performance is seen as a closed loop system composed of the user and the VME. The control interface must be designed to be as natural and easy-to-use as possible for quick responses to the ongoing music, and the world around the user must contain the right information and convey them to the user in an intuitive manner for acceptable controllability. The display must also be “vivid” in the sense that it must leave the user with a strong musical impression so that one remembers the “essence” of the musical content. In the past, several VMEs had been proposed [20]. None of them, of course, flourished to the extend that YouTube, Rhapsody, Dailymotion and similar have done, providing the means for effective navigation, organization and reproduction of music. They offer integrated environments for multimedia diffusion and, consequently, they do not only compulsively mold music trends, but also offer scientific advances on how to manage the huge volume of available music information. Kessler and Schafer [19], describe YouTube as a hybrid information management system.

First of all, YouTube must be seen as a new practice of a mashup library. In fact, it reflects the actual state of the Web in our days: it contains a huge amount of multimedia clips. As long as these clips are enriched with new and old digitized material, this unlimited collection, if properly preserved and managed, can also be considered as an archive too. The commonly accepted term for describing the innovative nature of YouTube is: the biggest, ever, online repository for audiovisual digital content.

IV. EVALUATION RESULTS

The evaluation of specific Computer Music interfaces is based on the previously mentioned usability criteria. These criteria however are adjusted to the specific communication content of mobile interfaces. The evaluation is calibrated with the following ratings of confidence whether a task can be performed:

- : weak confidence, +/- : plausible, + : strong confidence.

Interfaces

The usability criteria for the category of Computer Music protocols and specifications has to do mainly with the ability to simulate a broad range of musical data, to perform them acceptably and to expand to alternate musical forms (Fig. 10 - see amongst other, Nielsen and Budiu [21] for more). An evaluation of some schemas is shown in Table 1.

By the term simulation is described the ability to render musical sounds close to the real time performance data.

By the term interconnection is implied the ability to communicate with other digital musical devices. By the term expandability is described the ability to engulf alternate musical systems and events.

Table 1. Usability evaluation of Computer Music protocols on their ability to simulate alternate musical sounds.

Protocol	Simulation	Interconnection	Expandability	Acceptability	Learnability
MIDI (Industry standard)	+/-	+	-	+	+
Mobile Device Interface	+	+	+	+	+
Extended MIDI	+	+	+/-	+/-	+

By the term acceptability is measured the propagation of the protocol to alternate musical traditions users. By the term learnability is implied how easily the users of a specific product learn to produce alternate musical sounds and predicates.

Score Writing and Production

In this combined category, the evaluation criteria are adjusted to the pool of Computer Music users attempting to compose not abstract CMN melodies but melodies which will be performed and propagated to listeners of alternate musical systems. For instance, the music around the Mediterranean basin has been taken into account.

Also, hardware incarnations of such systems were considered; the basic criterion for their acceptance is the existence of a corresponding software module which at least can create notation or symbolic scripting of the performed music. For instance, if a keyboard performing Arab or Byzantine tunes is encountered, it is prerequisite to have software module that can write melodic lines according to this system. It is desirable but not obligatory for these systems to communicate.

The comparison of such systems is performed in Table 2. The well-known ISO/DIS 9241-11usability criteria are applied.

Some variations and extension of these criteria have to do with:

(a) Whether the system has room for symbolic representation of the alternate musical form.
(b) Whether the system is learnable for users expressed mainly in alternate forms and not in CMN.
(c) Whether the produced sound or the symbolic scripting of a melody are close to the alternate music predicates.
(d) Whether the system is modular and can co-operate with other Computer Music instruments and gadgets.
(e) Whether expert users of computer software and alternate music theory and practice can produce alternative music.
(f) Whether the listeners of alternate music forms accept the audio result of the simulation.

Table 2. Usability evaluation of Computer Music software modules on their ability to track down alternate musical predicates and to produce adequate sounds.

Protocol	Simulation	Interconnection	Expandability	Acceptability	Learnability
MIDI (Industry standard)	+/-	+	-	+	+
Mobile Device Interface	+	+	+	+	+
Extended MIDI	+	+	+/-	+/-	+

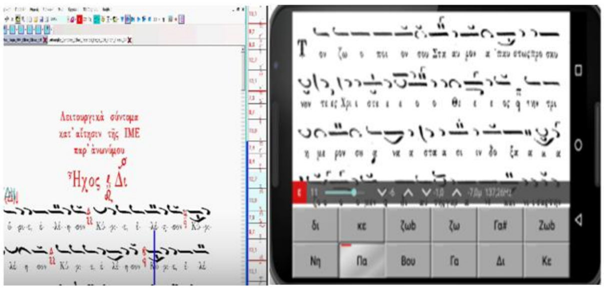

Fig. 10 Examples of alternate systems that can reproduce specific melodies. Left, MELODOS, a system for reproducing Byzantine Music for desktop computers. Right, ISOKRATIS, a more versatile Android based system, with feedback and base singing note recognition characteristics, for Byzantine Music melodies.

Evaluation Results

Already several prototypal, commercial and research projects have been focusing on alternate music representation, authoring and scripting. It is expected soon that the advances in HCI, based on the heat of Mobile Device Interfaces, will enable the production of commercial products that can compete the more than a decade old Western Music quiver. Since the Western Music interfaces have a very interesting evolution from the HCI point-of-view, as they pass to the new paradigm of Mobile Device Interfaces, a promising future is shaped for alternate and augmented reality paraphernalia that are set to shake for good the global music community.

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