Evolving Patterns of Human Interactions

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Abstract—Technology provides a way to communicate, and that desire is clearly one of the driving factors for which devices are created for human-to-human communication. In this paper, we specifically address the interactions technology developed facilitating human-human communication. As we survey this technical field patterns emerge just as devices or technologies were developed, and rejected. We are now left with phones which can be compared to mobile computers, and computer tablets which can easily make a phone call. The desire to provide similar functions on the go has led to homogeneity of the product which just a few years ago were quite different. As we look at this from complex systems point of view and review what has happened over a larger period of time, we propose that desire to communicate has always been a main attractor and driving force of development of technology as we summarize how sensorial interactions have been added to technology and/or devices. Our analysis show that rejection of technology is based on how the product is perceived, and that is not easy to predict as an attractor, as successful product in this case, can result in cascading effect and non-linear focus of similar technology.

Keywords- patterns: Patterns of Interactions in HCI

I. INTRODUCTION

Over the past several decades, technology has greatly expanded the ways in which people interact with it, other people, and the world as a whole. While interactions in the past may have been largely limited to one-way simple audio or video communications across bulky devices, modern technology has allowed for a large increase in the amount of interactivity, while also increasing the types of interaction to include a variety of ways to convey information using all five senses. In addition, reach of interactions has grown dramatically. The results of performing a simple action, such as talking or gesturing, can cause immediate reactions from other systems or people around the world.

With the massive growth in popularity of the Internet, the number of ways in which people interact via technology has exploded with clouds on the way. In the past, most interactions were focused around entirely one-way communications, such as radio or television broadcasts. In these cases, a simple stream of information was delivered to a user, who would then passively experience it. The provider of the stream could dynamically change what information they were providing at any time, but it was impossible for the receiver of the information to signal to the provider to do anything specific.

Similarly, the provider had no real way to monitor the receiver (or in the case of broadcasting, many receivers) to know what effect that their stream of content might be having.

The availability of different communication methods has also dramatically increased, largely due to the ubiquity of low-cost computing, as well as high-availability networking. In the past, widespread information distribution was limited to a small subset of people who had access to production facilities, broadcasting towers, printing presses, and so on. Now, anyone with access to the Internet from a variety of devices including cameras, phones, and computers can generate and share content with anywhere from one to a nearly unlimited number of people, taking advantage of free or low-cost services.

However, as the number of types of communication with both people and technology has increased, so has the difficulty in determining which types of interaction are actually palatable and desired by people. Often, a new type of complex technology will be developed which seems interesting at a glance, and which functions exactly as it is designed to do, only to be widely rejected by people due to some unforeseen problem. In addition, this can cause a misunderstanding as to why the technology was rejected, causing it to be temporarily abandoned due to thinking that people dislike the entire idea, when it was actually only a small, fixable issue which had caused the rejection. For example, mobile-tablet computers are currently attracting a large amount of attention, and are selling very well to consumers. However, this is not the first time tablet computers have been developed and brought to the market. Around a decade ago, very similar devices were created and sold, but were largely ignored and ultimately failed to draw people in. This is a demonstration of how seemingly small issues, such as a touch versus stylus interface, or size of screen, can cause widespread acceptance or rejection of a technology, though it is often difficult even in hindsight to see why people liked or disliked it. Similar stories can be told for things like video-phones, or PDAs, and even the Internet which have existed in various forms for decades, but took several generations of attempts before finding a combination which would cause widespread, and often very sudden, adoption of the new technology. In most cases, the only way to see how well something will do is to implement the idea, then test it with real people, and keep trying. With each iteration of such technology, the device or technology becomes an attractor and
certain features start to emerge as expectations, as new features are added.

II. DESIRE TO COMMUNICATE AND TELEPRESENCE

Telepresence is the concept of allowing someone to feel and act as if they are at a remote location and is our focus. This now encompasses a very wide range of technologies, from simple audio and video presentation, to using various forms of robotics and mobile phones which allow someone to perform physical actions despite not being physically there themselves.

For telepresence [1,2] using phone, only an attempt at conveying a single sense, sound, is used. Due to this, the illusion of each group of people being in the same place is obviously quite thin. A simple visual check will let a participant know that everyone involved in the call is obviously not in the same room. If someone at the remote location is talking, the only effective way to tell who is talking is by the sound of their voice. This can be largely affected by the quality of the speakers, microphone, transmitting equipment, line quality, and the familiarity of the people talking to each other. Even though the primary content is being transferred successfully, the failure to bring the ‘small’ details across as well causes a dramatic drop in the effectiveness of making people feel as if they are actually in the same room.

Yet another concern is how many people are attempting to connect to each other, the locations they’re connecting from, and how many locations are involved. In the above scenario, two homogenous purpose-built locations are used, each containing their own group of people. Today, far more complex situations can arise, where multiple locations are involved, each with their own specific sets of capabilities. Simpley connecting two people together is no longer considered impressive, or even acceptable. Multi-way connections between vastly different devices with varying levels of capabilities are now expected, as well as being able to share those capabilities beyond simple voice and video transmissions.

A. Audio

Audio has been used to remotely communicate with other people for well over one hundred years and audio has been the earliest to be delivered to everyone and has been all pervasive. The most widespread example of this is the telephone system, which expanded around the planet in order to connect every major, minor, and remote location.

1) Audio Technologies

The most basic form of two way audio communication involves each person having a microphone and a speaker, each of which are connected to the other person’s microphone and speaker over some medium. While the medium has changed drastically, most phones still continue to use the same basic single speaker and single microphone configuration today.

a) Evolution of the Telephone System

The original phone system made use of analog lines forming a direct connection from one phone to another, with the path from one phone to another being changed via manually operated switchboards. In the modern system, landline phones still continue to use analog connections in order to maintain backwards compatibility, but only for the connection from the phone to the telephone office it is connected to.

Cellular phones are now very common, with people often choosing to forego landline phones entirely. Although primitive phones did make use of analog technologies, these versions have all but disappeared. Almost all modern cell phones use digital connections between the phone and the tower, leaving the only analog components of the system being the actual speaker and microphone on the phone itself.

b) Internet Phone Systems

With the near-ubiquity of the Internet in many parts of the populated world, people have been developing and using the Internet for audio communication for well over a decade now. These systems avoid using the old phone system entirely, and communicate directly using IP packets. By using the Internet, these systems are able to easily integrate other features since the medium is capable of carrying generic traffic for anything, as opposed to phone-networks which were originally designed around voice alone. Some systems attempt to integrate both Internet-based voice communication as well as the telephone system. These systems typically operate over IP, but contain a phone gateway allowing calls to be connected to the phone system, or to allow calls from the phone system to be bridged on to the Internet.

2) Compression

Uncompressed digital audio still consumes a considerable amount of space, with an hour of CD-quality audio taking up around 700 megabytes. Lossless algorithms, such as FLAC, tend to reduce the size by half or better, though this is still relatively large. Far more common are lossy algorithms, which sacrifice perfect quality in order to achieve significant gains in compression, often up to an order of magnitude better than uncompressed. Most of these algorithms are based off of psychoacoustic models, in which an audio source is split into different frequency bins, then compressed at varying amounts based on how well human ears can hear that specific frequency. Frequencies which are outside of normal hearing ranges are dropped entirely. Popular algorithms such as MP3 and AAC are intended for use with music, and are tuned to capture a wide range of frequencies. On the other hand, many telepresence systems are intended for voices alone. As a result, additional algorithms intended to capture speech more effectively, such as Speex and Silk have been developed.

3) Speaker and Microphone Configuration

The number and placement of speakers and microphones is largely dependent on the type of system they are being used with. The other typical configuration is intended for groups, with a speaker and an omnidirectional microphone combination placed in the middle of a table or on a wall in order to allow multiple users to talk in to, as well as to hear from. The problem with this configuration is that the speaker is not isolated from the microphone, resulting in a feedback loop unless additional processing takes place. This becomes even more important when there are multiple locations participating in a call, as any one location can cause a
feedback loop, resulting in a large amount of noise for all participants.

4) Positional Audio

Another aspect which has been growing in popularity is various forms of positional audio. Two-speaker systems have been in use for a long time in order produce a basic one-dimensional sound plane, typically used to enhance music recordings. More recently, additional speakers have been added to movie sound systems, expanding the sound field to two dimensions by adding rear speakers. The most common format for this is ‘5.1’, indicating five full-range speakers (center, front left, front right, rear left, rear right), and a limited range low-frequency effects (LFE) channel. More recent advancements have added additional speakers, including dedicated side channels placed directly to the left and right of the user, as well as increasing the bandwidth of the LFE channel to be a full-range channel. These systems are known as ‘7.1’ or ‘8.0’ style systems.

Although such systems are very effective at providing an impressive range of sound, they do require additional equipment, and careful placement within a room, thus restricting their usage. Other techniques have been developed which attempt to produce the same effect for a single person wearing headphones using only two speakers with HRTF functions providing 3D audio cues.

B. Video

Video is now a very common element of telepresence systems. Although previously limited to high end systems, video cameras now range in quality and price from very expensive cameras intended for television production for several tens of thousands of dollars, down to web cameras intended for home computers for under $25. While a very expensive camera may have very powerful zoom features intended for use in an auditorium, or be rigorously tested so that it can be used in harsh conditions or for very long periods of time, neither of these features are relevant to a home user intended to simply use the camera in front of their home computer.

1) Video Technology

Originally, web cameras were limited to lower resolutions such as CIF (352 x 288) or QCIF (176 x 144). These resolutions were comparable to broadcasting standards and recording formats at the time, such as NTSC and VHS. Other factors, such as low or unstable frame rates and poor color reproduction were also common. These issues were caused not only by relatively cheap components, but by low speed interconnects such as serial and parallel ports, as well as the initial version of USB. In these cases, even if the camera was capable of higher quality or faster image capturing, sacrifices needed to be made in order to display the video stream in real time. These sacrifices usually came in the form of dropped frames, or over compressed images, leading to low color depth and image blocking caused by compression algorithms. Today, most of these problems have been solved. New interconnects such as USB 2 and Firewire alleviated bandwidth concerns, allowing connections capable of hundreds of megabits of local bandwidth. In addition, improvements in networking have also increased the amount of bandwidth found in an average home or office. It is now common for home users with nothing more than a simple router intended to share their broadband connection to have several gigabit wired links, and a wireless network capable of over one hundred megabits of throughput. Due to this, self-supporting cameras are now becoming common, no longer requiring a separate computer at all.

Newer, more efficient video compression techniques have also been developed; utilizing improvements in computing power to drastically reduce the amount of bandwidth needed while improving image quality. Currently, the most commonly used protocol is known as H.264. H.264 is the result of several different standards and research organizations, leading to several other names such as Advanced Video Codec or MPEG-4 Part 10. H.264 has seen massive adoption by different industries, from ultra-high quality video used for Blu-ray Disc movies, down to video which is intended to be viewed on cell phones. Due to this wide range of uses, many devices now contain hardware implementations designed to assist in the encoding and decoding of H.264 video, allowing it to be used on devices which do not possess an excess of general purpose computing power. Some web cameras now contain such hardware, allowing the task of compressing the video to be offloaded to the camera itself, rather than using the CPU of the host computer.

Now, liquid crystal display (LCD) technology has become the dominant technology, allowing for extremely thin, light, and low power displays. The size of LCD displays have been scaled up to well over 100", as well as down to the size of individual keys on a keyboard. Originally, LCDs suffered from poor contrast and refresh times, though these problems have largely been addressed with modern LCDs operating at refresh rates of 240 Hz. One downside compared to CRTs is that LCDs must have a fixed resolution. Due to the nature of CRTs using an electron gun controlled by magnets, variable resolutions were possible, at the cost of convergence and geometry problems. LCDs on the other hand always have perfect (limited) geometry, but at the cost of using a fixed resolution. However, pixel density has improved to the point where rescaling images to be displayed on screens with their non-native resolution is no longer as visually distracting, helping to mitigate the effects of this limitation. The ability to create small, low powered screens has drastically increased the feasibility of portable interfaces.

Finally, the systems used to generate the images being displayed on the various types of screens have improved as well. A standard video adapter in a home computer can now drive at least two displays, with some adapters being able to power up to six displays. Multiple adapters can also be added, allowing an entire wall of different screens to be controlled by a single computer. As a result, the amount, size, and placement of screens and cameras is now no longer significantly restricted by technological limits, and largely up to the designers and users of telepresence systems.

The latest technology being added to displays are various forms of stereoscopic imagery. Traditionally, this has been accomplished with some form of glasses which the user must wear, either active or passive. In an ‘active’ glasses system, the user wears a pair of glasses which are in some way
synchronized with the display system, usually through IR or RF. The display system then plays the video at double the intended frame rate, with every other frame being intended for either the left or right eye. The glasses then black out the image for the eye for which the image is not intended for, allowing each eye to see a different video stream.

A ‘passive’ glasses system uses the same concept, except that it moves the complexity from the glasses to the display system itself. Instead of the glasses being able to shut and open in synchronization with the display system, each of the lenses is polarized in a different orientation. This allows the glasses to never need to change state. Instead, the display system now must be able to produce every other frame using the light which is polarized in the correct orientation for the intended eye. For an active system, the glasses require a small electronic system within them which can synchronize properly. Passive glasses only require polarized lenses, which are very cheap. On the other hand, the display for an active system only needs to be able to produce a video at double the normal frame rate, which is a very common feature on most new displays. A display which can be used with a passive glasses requires a complex system allowing every other frame to be polarized differently, which up until recently was a feature restricted to high-end movie projectors. New systems requiring no glasses have also been developed, based on using lenticular screens in order to display different images towards each eye. However, these systems tend to have extremely specific viewing angles, otherwise the effect is broken, letting the user see double images with both of their eyes. Although using separate images per eye to create a 3D effect can be very convincing, slight inaccuracies in what the brain thinks it should be seeing can lead to headaches, and feelings of fatigue.

2) Display Configuration

Displays can be set up in a large variety of ways, involving different uses and positioning. This will largely be determined by the intended use -- a simple one-on-one conversation between two people at their home computers, or a home user remotely watching a conference as if they were in the audience.

a) Single Display Systems

For a conference involving only two people, using one monitor and one camera could suffice. However, this is rather limiting, as it does not allow for each person to do anything else while in the conference, or to allow for more than two people to be in a conference at a time. As a result, most systems allow for more elaborate controls, either through using multiple windows on a single monitor, or using multiple monitors. Automatic systems attempt to determine what the users would want to see on their own, without explicit interaction. The most common method is by listening to the audio of the conversation in an attempt to pick up who is the dominant speaker at any given time. The same concept can be applied to video, attempting to detect when a large contrast in motion or brightness change has occurred if the cameras are watching an event with high levels of activity.

b) Multiple Display Systems

Many systems and users opt to use additional displays to allow viewing more remote users at the same time, as well as to incorporate other features. For example, a system may have an elaborate set of controls, or a chat interface. Adding more screen space allows for these to be seen and used without needing to interfere with the video streams of other participants. A common feature in telepresence systems is using what is known as a ‘confidence monitor’. A confidence monitor lets them know that they look how they want to look. Another use for additional displays is to allow a user to do separate work on their computer while participating in a conversation with other people.

c) Camera/Screen Positioning Disparity

One noticeable problem which must be taken into account is the positioning of a camera recording a local user versus the positioning of the screen displaying a remote user. Due to the disparity between the center of the screen and the camera, this will cause a local user who is looking directly at their screen to appear to be looking slightly downward to the remote user, instead of looking at them as would be most natural. This can be solved by simply placing the camera as close to the center of the screens as is reasonably possible. More elaborate systems, such as ones created specifically for teleconferencing by companies including Cisco and Tandberg, place the camera hanging down in front of the screen slightly. This will obscure the top of the screen slightly, but allow for less of a difference in angle between the camera and center of the screen. Another method is to move the screen further away from the user. Another approach is to attempt to visually correct the image being captured by the camera so that the face of the person will appear to be looking forward. This involves various facial detection and reconstruction techniques and can become complicated. Additionally, if a user is using multiple displays, such as if they are connected to several different people at once and watching all of them, or if they are using other displays to work with and present material to other people watching, this will again cause the issue of the user appearing to not look directly at the other users participating in the conference.

d) Multiple Users Per Location

So far, the previously mentioned configurations have assumed that only one user would be at each location. Having multiple users at a single location also introduces new problems with how the system will be controlled, both due to having multiple people attempting to control a single system, as well as having more people possibly sitting further away from the system.

e) Multiple Cameras Per Location

It is possible to use more than one camera per location. This may be done in order to allow switching between views of that location, possible to allow more freedom of movement while still keeping the area covered with optimal camera angles. Alternatively, this can allow for more panoramic or complete views of an area.

C. Touch

Simple physical interactions such as pressing buttons, or sliding a finger across a touch screen, are common methods of interacting with or controlling telepresence (and most other) systems. However, the idea of actually transmitting the sense
of feeling (such as an object) from one person to another remotely remains relatively unexplored compared to efforts put towards sight and sound.

1) Touch Transmission Systems

During the early 90s, several technologies were developed as 'virtual reality' applications, which were based on the idea of realistic shared virtual world. Ultimately, none of the technologies required to meet this goal were advanced enough at the time, resulting in ideas left at the incubation stage. However, the individual components of such idealized systems have continued to be developed, such as lightweight displays, realistic-looking 3D renderers, and limb position detection systems, such as datagloves. Datagloves can provide 3D haptics and provide basis for tele-surgery experiments.

D. Smell and Taste

Smell and taste have remained the least explored senses for use with telepresence, largely due to the difficulty in both detecting and reproducing them on the fly. Detecting what something smells or tastes like is a complex chemical analysis process, requiring equipment typically found in a laboratory, rather than in a home or commercial setting. At the same time, producing mixtures of liquids or gasses to stimulate these senses is also complex, as the chemicals required to produce a specific flavor cannot be mixed together easily. Instead, research continues in this area in order to determine why certain mixtures taste or smell the way that they do, as well as trying to determine a small, common subset of chemicals which could be used to readily produce a wide variety of flavors.

1) Smell Reproduction Systems

Personal systems generally involve some sort of harness which allows a smell to be directly applied to a person’s nose. These are more of a proof of concept, rather than as practical system, as it requires a significant amount of equipment, such as chemical reservoirs and pumps. These can either be built in to a workstation, or can be a portable system, placed in a backpack. Both can lead to concerns about sanitation, as well as being fashionable, as some such systems generally involve placing a tube in to the user’s nose. Although such systems are interesting, they remain largely impractical.

Area systems do not attempt to affect users individually, but rather focus on changing the smell of the nearby area, such as a room. These systems work by emitting scented air when commanded by some other computer. The advantage of this is that an entire group can be affected, allowing for a shared experience. The downside is that there is no easy way to clear a smell out of the area to replace it with another new scent. Some attempts to solve this problem involve using specific air flows within a room, so that air is quickly cycled out of a room, preventing stagnation, or to emit certain smells known to ‘reset’ the human smell senses, such as coffee grounds. Unlike the personal-based systems, area-based systems are currently far more practical, with commercial implementations available.

III. Interactive Systems

Just as different methods for communicating with other people have developed, the number of ways in which to interact with systems in general continues to grow [1,2]. Traditionally, simple touch interfaces such as buttons and knobs were used to control devices in simple ways, such as turning them on and off. Later on, basic sound interactions became possible, first simply through recording a voice for reproduction, and then for use in actually commanding devices to perform some action.

Touch and sound remain the primary methods of interface with devices today, as they are by far the easiest senses for humans to control. Although people certainly have different smells and tastes, these cannot be easily controlled by humans, and as such are impractical for general use at this time.

A. Touch

Buttons, knobs, and other similar widgets provide flexibility and simplicity. Key pads are collection of several buttons and have been in place for a while. Pointers (such as mice) provide a way to implement 3D-pick techniques. Touchscreens combine the pointer input method with a display, are considered natural as users can directly touch the items on the screen they want to interact with. Gestures allow users to use their own body as controllers. Some of the problems with gesture-based systems are accuracy, and accidental erroneous matches.

1) Force Feedback

Force feedback devices attempt to not only accept input from a user, but also to provide feedback in form of vibration, resistance, or physically pushing back against the user. Force-feedback joysticks have been used in games to provide greater immersive experiences such as requiring extra force when a character is moving through a difficult area, or to represent extra forces in a flight simulator. Most game systems now incorporate at least some form of vibration, which can be used to get the attention of the user when something sudden happens, such as their character bumping in to a wall.

B. Sound

Sound can be used to control devices in a number of ways. Full control of a system using only natural language speaking has been featured in science fiction novels and movies for a long time. Though actual technology has a long way to go before such a system is possible, limited versions now exist which are capable of performing different actions based on spoken phrases.

1) Sound Detection Systems

The most basic systems using sound as an interface do not attempt to analyze the waveform for specific words or meaning, but instead simply look for the existence of sound. For example, a lighting system in a house may automatically turn itself on if it hears a sound, such as people returning home through the front door. Many other examples are possible.

2) Vocal Detection Systems

Systems which attempt to actually understand what is being said, and possibly who is saying them, are a large topic
of research at this time. Simple versions of voice detection can match an incoming sound to an existing database of pre-known commands. This alone presents difficult pattern-matching problems, since each time someone speaks a command, the recording will be at least slightly different. Simple binary matching is not useful. Instead, frequency analysis is used in order to determine the probability of a match.

More advanced systems have the capability to handle dynamic elements, requiring new patterns to be developed after the device was initially created. Since users can change the contents of their player, the system must attempt to dynamically create sound patterns for each of the songs on the device on-the-fly, or to listen to the incoming sound and break it down in to a series of letter which can then be match using text-based techniques.

Beyond simple commands, systems can try to allow for more natural language. This is often done by attempting to simply filter out the less important words, assuming that they are just filler not needed to convey the actual meaning of the command. A system which can fully understand, comprehend, and respond based on completely natural and arbitrary language remains an unreached goal. Such a system needs to be able to recognize individual phonemes, then convert them to words, convert the words in to phrases, then to break the phrases down in to a grammar, then finally attempt to actually understand the meaning behind the phrase.

Usually sound is not a prime candidate to be used as a control mechanism for teleconferencing systems, as it would be difficult to separate the sounds which are intended for controlling the system from the sounds which are being transmitted to other parties.

IV. IMPLEMENTATIONS

Several popular systems for interacting with other people currently exist, either as cheap or free implementations. This section is by no means comprehensive, but describes only a few of the current systems which are popular at this time and covers several different styles of interaction, even while using similar methods of interacting with the senses.

A. Facetime

Facetime is a relatively new platform for social interaction created by Apple Computer. It is focused around simple video conferencing. Unlike most other systems being developed currently, it has a very low feature count, allowing only one-on-one calls between people, making it similar to older implementations of video phones. Additionally, it only runs on products created by Apple, meaning that it is not very useful for trying to connect a large network of people.

B. Google Plus Hangouts

Google Plus is also a relatively new system. It is primarily intended as Google’s new social networking site, intended to compete with similar sites such as Facebook. However, it also contains a video conferencing aspect, known as ‘Hangouts’. The idea behind Hangouts is that it is very easy to jump in and out of multi-person conferences composed of anyone in each other’s ‘circles’, which are Google Plus’s version of a friends list.

C. Ventrilo, TeamSpeak, and Mumble, Skype

Ventrilo, TeamSpeak, and Mumble are three voice-based popular clients and are well tested. These systems were all originally built to assist with online gaming, and as such have features to assist with that goal. Unlike many other clients today, these tend to use a ‘push-to-talk’ strategy, requiring a person to press some button in order to indicate that the client should begin transmitting their voice. Skype is a very popular Internet conferencing program. Skype has developed their own voice compression technique, known as SILK, rather than use existing codecs.

D. EVO

EVO is a lesser known collaboration system created at the California Institute of Technology. It is intended as a research network, and is in wide use by several labs focused on high energy physics. The primary client for connecting to this network is called Koala, which is written Java, allowing it to be used on several types of personal computers. Unlike the other networks, EVO is not intended for widespread usage, or as a social network. It is intended for more serious, research oriented purposes. EVO is under heavy development, and regularly sees new features being added.

V. CONCLUSIONS

Control and interaction also continue to be expanded on. Currently, the most common remote control technique seems to be simply sharing a remote version of a computer desktop in order to allow someone to work on that computer as if it was local. However, other methods such as unencumbered gesture commands, and wireless RFID tagged objects, can also be used to control systems either locally or remotely. Possibly the biggest change in interaction and telepresence technologies is that people no longer expect to need to obtain devices which are dedicated to some specific technique or protocol, but instead assume that almost every device is capable of it to some degree. As technology gravitates toward the best idea, all devices, for example personal computer, or cell phone, or music player, will be able to connect to other people in some way. Ultimately all such efforts are gravitating towards desire to communicate with others separated by space and time, as well as perception of convenience. This will continue to remain the main attractor in future.

VI. REFERENCES


