Internet of Persons and Things inspired on Brain Models and Neurophysiology

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Abstract

Living in the twenty first century and being part of a modern society entails being entirely acquainted with the Internet. Business success, research and study rely on intense usage of the Internet, doing most of the activities based on information gathered at the Internet and using diverse kind of services available. The recent development in devices and services, either for computational or mobile operations, has revealed a diversity of paths for the Internet to have impact in our lives, either professional or personal. Without notice, every activity we do is becoming somehow connected to the web in multiple forms that can range from the search of information, the communication between people and information storage at the cloud. Everything seems to be so useful and so destined to promote our life and supply our needs for work, learning or recreation activities. As for the social aspects, Internet has a multitude of opportunities to communicate, to share ideas and to get feedback or news, as it happens, with online newspapers, the blogosphere and social networks. With this pervasive and sometimes implicit integration of the Internet in our lives, we are migrating from traditional way of life to an Internet supported lifestyle with many daily Internet based activities executed by each human being. However, despite this movement of almost putting us in the innards of Internet, we didn't yet notice a structural change in such infrastructure to cope with our human nature and, in particular, with the way we perceive and feel the world. This article exposes the vision of the authors for a possible shift in Internet paradigms towards effective support of the human nature.

Keywords: Internet of Things, Neurophysiology, Brain models.

1. Introduction

The success of an enterprise, a given project or even a person, depends on knowledge bases, on the ability to retrieve relevant knowledge and ultimately on how to handle that knowledge towards effective decisions, wise management and thus successful outcomes.

It is noticeable that the technological advances in the last years established a close relationship between humans and devices. Intentionally the word device is so generic that covers technological advancements in so many areas as we can find in our daily activities, either professional, or personal.

The development of many industrial branches devoted to lifestyle consumer, supported by enthusiastic scientific research, has flooded the market with products directed, especially, to younger people or active professionals.

In parallel, and supported by physical devices, Internet is everywhere for every purpose, with an exponential growth of users, along with all kinds of applications, that made Internet an unavoidable tool, an asset for business, research and social life.

The wide usage of Internet in different regions, by different cultures, covers almost every aspect of human life. This may lead to the idea that a good level of interoperability exists between humans and Internet.

However, even a superficial observation, trying to identify the similarities of Internet content and that of the human brain, confirms that there are yet no parallels between the acquisition and support for sensorial and emotional information from both sides.

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It differs in obvious aspects, as it appends with devices and sensorial organs, or between neurophysiology and electronic circuitry. It also differs in the way computers and the brain acquires, stores and handles information. All differences, that makes them two worlds apart.

Above all, we notice that, in what regards to information retrieval, at the Internet we find images, movies and sound. In contrast, we perceive the world with our rich sensorial experience that, in its essence, comprehends five senses plus a multitude of variants over those primary five.

Looking from another angle, our life is mediated by emotions; they determine our decisions and our relations with the others and with events places and objects. It is noticeable that at the Internet there are no infrastructures no services and no data model to support those human aspects.

Finally, we understand that the Internet addresses poorly the needs of humans as its architecture reflects only a technological support for communication and storage of information and knowledge. Oddly the Internet is for human usage, and in many cases it works like a business or a social network. Besides those facts, it lack of interoperability with major human features, as the ability to sense and feel emotions.

Humans need emotions. Humans feel with their senses, their body and their minds and it is curious that surfing the Internet or many online activities are widely viewed as a global high tech adventure and, therefore, could be considered a form of sensation seeking [1].

The present research seeks to understand what can be changed in the interaction with the Internet, explicitly in what regards to handling sensorial and emotional information. It aims to open channels to improve interoperability between the Internet and our nature, which is based in the Human Brain and its neurophysiological setup.

This article starts by making, in section 2, a rational about Internet and what we need and what is the challenge for our usage of the Internet. Then in section 3 an exploration is made on human neurophysiology and in a selected model of the brain. In order to cope with the proposed challenges, a new Data Model is proposed, in section 4, to cope with sensorial and emotional data. A new Architecture based on the lessons learn from the brain is proposed in section 5. Then in section 6, an exploration research path leads from conventional Internet to the proposed human oriented Internet of Things, which also results in a new type of search engine that includes sensorial and emotional information. Finally we draw conclusions on section 7, with the lessons learned and potential uses for the new paradigm of information retrieval and object representation and its benefits for people and business.

2. New perspectives of the Internet

The need of accurate information, at the right time, has assumed a vital role in citizens' daily life. The power of information is such that most of decisions made in different sectors like science and technology, economics, and business development will be based on information that has been generated electronically.

Information has become a key asset of an organization for its' progress [2]. In order to provide key information according to the needs of organizations and citizens, knowledge management frameworks where established to supply that permanent hunger for information.

By so many remarkable specificities, internet has become the most popular source of information [3] and it means that improvements in information management can have an interesting impact, case we reshape information handling over the internet. Internet is used for many proposes from gaming to communication and these days so much on social networking and many other applications. But as for subjects like data handling, information deliverance or knowledge production we need to deal with files, symbols, webpages, in a word, objects.

We tried to understand how persons handle information, by means of the web, and how human neurophysiology and neuropsychology could be used as models for new ways of handling information and knowledge at the Internet. In trying to learn from the brain, research seeks for a strategy that goes beyond conventional information, which is based, mostly in images or text, sounds and movies.

We want a new perspective towards a more humanlike approach with new paths to get information and also new ways of handling information and knowledge by learning with brain's behaviours and in general

with neurophysiology. The research results aim to determine if a better characterization of source objects will allow more accurate searches and thus reduce misleading queries for the information we seek.

People should be able to reach information without the need to loose endless time in crawling over never-ending items just by the fact that they have a given keyword, even if that is completely out of the required context [4]. It means that improvements in information management can have an interesting impact in our interactions with Internet contents and services and will impact in the way we connect with others in our social online communities.

In our technological society, changes are needed and an ever-changing pace of novelty will bring new sights and new contents. But we could question about our abilities to reinvent the ways of dealing with information and knowledge over the Internet.

It could be confusing to mention information and knowledge in the same context but the level of interaction varies with business cases or social interaction. The fact that we hardly handle data and that barely we can have a pattern of knowledge and wisdom accessible over the Internet makes information the broader term for our regular experience using the Internet. It is in fact a term of wider spectrum and most general coverture that is why we need to use it when we would like to mostly use knowledge and wisdom.

In matters like data handling, information deliverance or knowledge production we need to deal with files, symbols, text and pictures, in a word, objects. And thus we selected those diverse objects as target for our research.

All these observations can be summarised in; we are using the Internet for multiple purposes and the way we use it does not match human nature; we are probably loosing too much time with misleading search results; there are examples from neurophysiology and neuropsychology that can be used as use cases with expected benefit for human computer interactions and for better serve the human proposes.

Then the challenges are, first; the need for a better Interoperability between our nature, our brain and our neurophysiology and the Internet infrastructure, and secondly; to improve data acquisition and knowledge management based on lessons learned from our neurophysiology and from selected models of our brain.

3. Learning from the Brain

A model of the brain that is largely accepted will be taken as an example to develop new concepts for object representation and knowledge management at the Internet. In particular, from previous studies carried by the authors [4][5], it is described what lessons could be taken that will inspire the design a framework for knowledge management and also new data models for the same purpose. We will explain how this solution is achieved using sensorial information as a driver for we will increase the probability of finding the desired knowledge and reduce the time spent to find that desired knowledge.

We then define the basilar premises for our proposal by defining a knowledge representation that copes with emotional and sensorial information as it happens ad the brain. With this conceptualization in mind we will extend the sensorial information to the five senses, or at least enable that potential and, when possible, associate emotions as they would be textually expressed or device captured, but this all comes from learning with existing information about the brain and our sensorial capacities, as described next.

Recent developments in technical instrumentation in the last century supported by skilled professionals have revealed much information about the physiology of the brain, many new theories giving ground to new theories for the brain functionalities and for human physiology in general.

The most antique execution of electroencephalography (EEG) revealed that brain activity was triggered by external stimuli; in particular it was observed that the input gathered from the eyes would mainly activate the occipital cortex [6]. , Magnetic Resonance Imaging (MRI) studies along with its functional variation (fMRI) have demonstrated the location of the visual cortex and where does the visual stimuli produce effect at the brain in comparison with the location of other stimuli [7].

All that equipment is able to generate physiological data either by image or electrical signals, which researchers can analyse and theorise. However, no matter how impressive the amount of data acquired by all

those devices can be, in some perspective, it remains deceiving, as there is no general theory of the brain and no universal model, even knowing that people's brain has the same physiology.

Our work consists, not in developing brain theories, but in picking selected models in this field and try to apply them to knowledge information systems. In this scope the Two-Stream Hypothesis gives us clues about how brain processes visual information. As mentioned before, on the Internet everything is mostly visual.

We receive images that are formed in the occipital region of the brain [8], then according to the Two-Stream Theory, the Dorsal Stream goes from the occipital lobe to the temporal lobe and is known as the "what stream". The Ventral Stream goes from the occipital lobe to the temporal lobe and is known as the "where stream"[9]. The dorsal stream will provide the identification of what are the objects in sight by comparing them with existing memories of objects and shapes from the past. The ventral stream will put that object in context as where that object is placed in a given place or scenario.

Both streams interact as the context will contribute to the possible identifications of the object and the nature of the objects imposes limits to possible contexts.

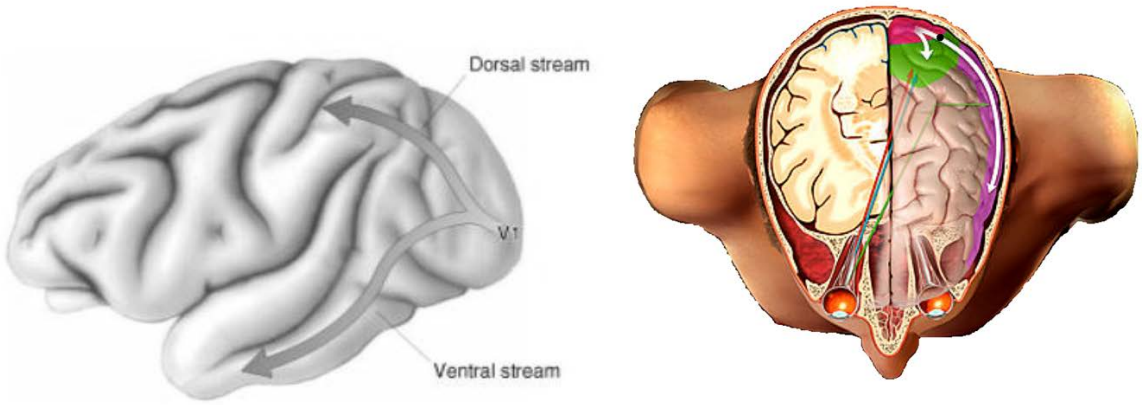

Fig. 1. Image forming in the Occipital Region of the Brain originating the two streams, Ventral and Dorsal.

There are two relevant findings in this theory; first we notice that a visual stimulus is a trigger for actions performed by the brain in trying to give meaning to what is seen and where it fits in real world. Then in following this two main directions, ventral and dorsal, it tries to give meaning to what is seen mostly by comparing with memories or known records of previous sensorial and emotional experience.

This process is composed of the analysis from visual image but then other associations are evoked as in the brain smell, sound, taste and touch are clustered in our memories. Also it is important to notice that emotions are part of the regulation of the process of acquiring information but also regulator of the retrieval process.

In summary the brain stores sensorial information along with emotions, establishing a network of connections that can be invoked by any of those instances of emotions and sensations. And that is the area where, from our research strategy, technology meets the brain.

The neurophysiological analysis and the functional view of the brain must be supported, by the computational side, by a number of tools that can be used to organize knowledge related to the different types of sensorial information plus the emotional data. In order to make it possible it is necessary the design and conception of an ontology that supports the new knowledge base instantiation composed by emotional and sensorial description.

Finally we face the fact that so far the Internet doesn't support and doesn't provide contents as needed, with sensorial and emotional information. Thus semantic annotation, either manual or using some automatism, can be used as basis of an early framework conception. As a consequence it can foresee the interoperability with other sources of information, like those retrieved by medical devices, or others, as described in the conclusions section.

The harmonization of different sources is also a necessary step and it can be mediated with existing ontological frameworks like those proposed by the Mentor Methodology [10]. Once established, a resulting ontology can be generalized and that will be the basis of the proposed framework for knowledge management. This baseline ontology will be regularly updated, according to the readiness of new technology to capture physiological data or, meanwhile, updated with user annotation and personal reporting of sensations and emotions.

4. Defining a new Data Model

The level of interaction that a user has with the Internet, either for usage of specific services or to communicate with persons thru the Internet comprises a wide range of activity that are not likely to be typified in patterns. However one characteristic is unavoidable to each and every user of Internet, that is the need to search and to find what we are looking for which is, so far, materialized in the usage of the search engines.

The importance of search engines for finding relevant information become so tremendous as we need to find information for our work and our study and that information is achieved, essentially at the Internet [11] by contrast to until 10 years ago where information could be found mostly in libraries of books with pages in paper. The results of the search of information establish the frontier between what we know and what is at the Internet.

What we are looking for and what we get, what we know and what we will know next are the sum and the result of our search activity and the effectiveness of something as odd as our search criteria and the performance of the search engine.

In general, searching the Internet consists in describing by words what we are looking for. Recently there is the possibility of searching for images similar to a picture, provided to the search engine. But the vast majority of our usage of Internet as an information system is based essentially on text information, even when the results include files, images or other multimedia contents.

The brain has other approaches to store, and later, to seek for information. Clinical researchers and other scientists have pursued ways to understand the brain. Many models have been constructed based on experiments and observation.

For hundreds of years most of the great classical philosophers like Plato, Aristotle, Spinoza, Descartes, Hobbes and Hume, had recognizable theories of emotion [12] and tried to develop cognitive models in order to understand how the mind works. No model is definitive and a permanent search for understanding of the brain is still under way.

The authors want to explore the usage of those lessons learned to knowledge management, taking widely accepted hypothesis. The primary lessons emerge from regarding human sensorial experience of the world and the flows that take us to learning and exploring and essaying how the information systems can be shaped in a similar manner. Then we are challenged to determine the benefit of taking a human centric approach to enrol with selected neurological models and assess its efficiency for knowledge management.

In practical terms we want to migrate from the classical repository made of text and eBooks, sounds, music and movies to the ability for a full acceptance of all human sensorial and physiological experience. That doesn’t mean solely to include smell, taste and touch but to accommodate human related information. Depicted in Fig. 2. is a simplified vision of this process that, ultimately addresses the human physiological reconnaissance of the world.

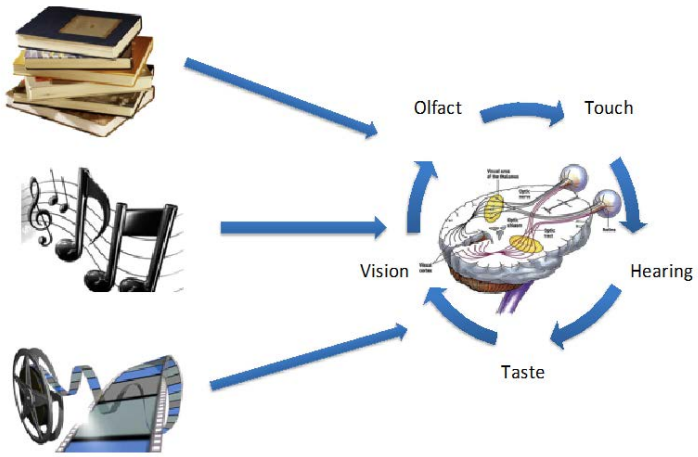

Fig. 2. Shifting Paradigm from 2 senses to a rich sensorial experience

In an IoT context, the same information source can be used to a wider range of applications as it can fit in new kinds of user demands. Enrichment of information will allow a more versatile appliance of available information to different contexts. In a similar way to the sensorial contents, emotional information will make the next step towards a humanized contents and enrolment and clustering of that information towards the needs of persons.

The current research as led to the concept of i-Episode [5] with the clustering of Emotions and Sensations related with the information collected about a person at a given time in a given place.

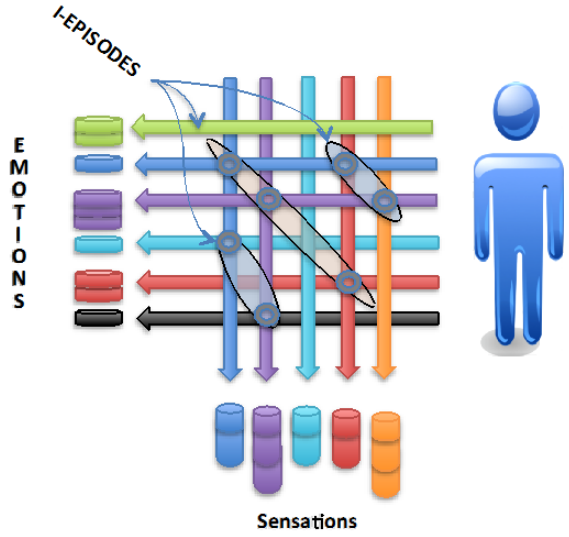

Fig. 3. The concept of I-Episodes as clusters of Sensations and Emotions [5]

The basis for the new framework is the proposed Data Model, which includes the ability to represent emotions and sensations, clustered for each person. Along with the ability to represent sensorial and emotional information for objects, a differentiating feature is the I-Episode that stands for Internet Episode and refers to the ability to represent, at the Internet, sensorial and emotional information for a given person. In what concerns to the I-Episode that that is a temporal gap during which information is collected. Without any specific boundary, it is supposed to collect information in the same moment, or related to the same event, linked and clustered in an I-Episodes.

The information that could be acquired remotely or by portable devices is collected for that given person or could be personally created by her. In practical terms if a person has a smell detector that could deploy the smell of alcohol and even take note of it's molecule, but if not, a person can state that there was an intense

smell of alcohol at that site. All that means that this new paradigm has sensorial and emotional data in its basis but is meant to build a DIKW towards Human oriented Wisdom as depicted in Fig. 4.

As there are so many different assumptions about the definitions and differentiations over Data, Information and Knowledge [13] we keep Wisdom as a Human capability and we focus essentially in collecting Data, assuming here raw data from sensors or generated by humans and Information is put at the level of the I-Episodes where some rational is made for the connections between sensations and emotions for a person. As for what concerns Knowledge, in the sense of this sequence DIKW, it is expected to result some Knowledge over the analysis, inference and predictability of sensorial and emotional information for Internet users.

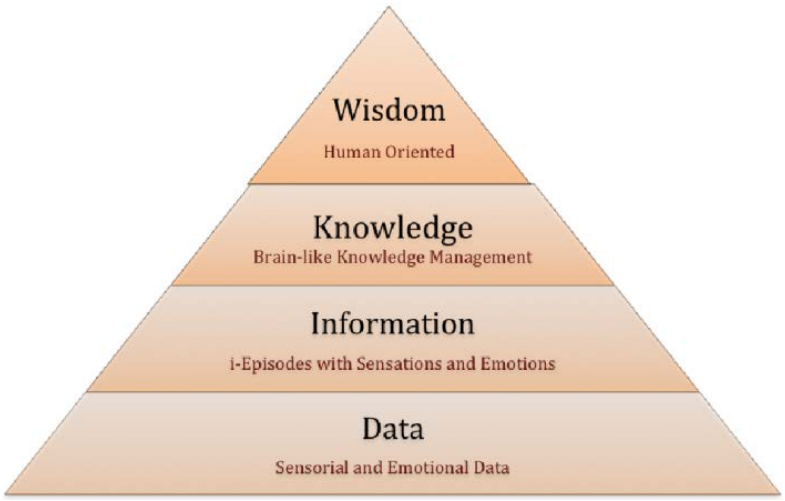

Fig. 4. New data model as base for the path to wisdom

With the concepts described so far and with the identified potential for a renewed data representation at the Internet taking in account the human specificities, it is then opportune to develop the architecture that supports such evolution. It is important to consider the rational of this framework, how the information is related after generated or captured and how it is achieved for further purposes. That is the reason behind the next section where such architecture is proposed.

5. Brain Based Architecture

The departing point for the proposed framework is to take the two-stream hypothesis has a potential model for handling information in innovative and fertile knowledge bases. The objective of the proposed framework is to retrieve sensorial and emotional information creating support for human oriented knowledge bases.

For the establishment of the proposed framework two paths were followed with a common goal towards new and more efficient models for information systems.

The first is by exploiting the retrieval and storage of information in an information System as it happens according to the two-streams hypothesis. This could be backed by semantically-based Web Map Mediation Services, a core of semantic and ontological tools for mapping [14], mediation, annotation and what else found needed for pursuing the most consensual and interoperable solution as possible.

The second, directly related with the first, consists in instantiating a knowledge base and harmonising it with existing information thus providing an ontological solution that includes sensorial and emotional information either by properly instantiate with retrieved knowledge or by semantic annotation of existing knowledge bases. The expected result in terms of construction and contents is a new form of representing information that will permit new acquisition opportunities and empower the existing knowledge. In terms of functionality new services can be deployed making use of sensorial and emotional information along of new opportunities for more ubiquitously searching and finding the desired information.

Comparing to existing solutions, we propose a framework that supports:

1) A new data model that includes sensorial and emotional information along with the usual text and photos.

2) A new approach for searching methodologies, on the Internet, by allowing new specific fields according to the proposed data model

3) A new ontology to facilitate standardization of the new and extended data model. As result from this framework we want to change the established paradigm of Internet object identification and characterization and, that way, supporting disruptive methods for knowledge management.

In view of the operational objectives for this framework in the possibility of storing sensorial and emotional information in our records, even if those are centralized in the conventional storage of pictures. The other objective is to enable the addition of diverse sensorial and emotional information to existing records.

The current research has developed support for the new kinds of information based on ontologies that need to be supported in some reliable infrastructure, as is the cases for the wikis or some other service that allows expansion of data annexed to pictures.

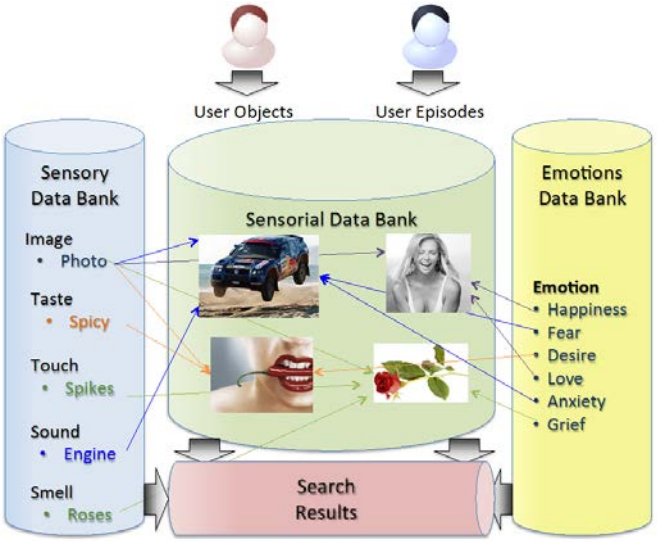

Fig. 5. Proposed Architectural Model

The proposed framework

There are three sequential steps towards the establishment of the proposed framework for knowledge management. In all cases the development of an ontology for emotions and its instantiation will be present and research will be done using the above-mentioned tools and services.

The first step comprises the usage of the existing search engines to feed the new ontology with sensorial and emotional information. That means a different approach to search events with result in retrieving information for ontology instantiation.

The second step consists on using the instantiations as a database for emotions and sensations, thus improving the ontology usage with semantic sensorial and emotional annotation. Finally the third step uses the infrastructure proposed by the previous steps but using sensorial representation and emotional information, this could be done with a new set of devices, some in development others to be deployed by new technological advances. The final step is a domain for future work.

The first stage that is being developed consists in presenting a new data model that includes support for sensorial information. That start-up will be supported by an annotation process that assigns sensorial metadata to an entity, with a link where the semantic annotation refers to ontology content [15].

The definition of the framework implies the creation of capacity to store emotions and sensations for linkage to objects or for describing events. At first emotions need to be described as text but later will be

possible to retrieve physiological signs associated with those emotions. As for the sensorial information, there are already formats that describe them without the need for text. The more obvious cases are images and sound, but it is also possible to describe smell and taste by molecular description. Also for tactile experience there are already some trials that is the case for the force- feedback that some games support for providing a better gaming experience.

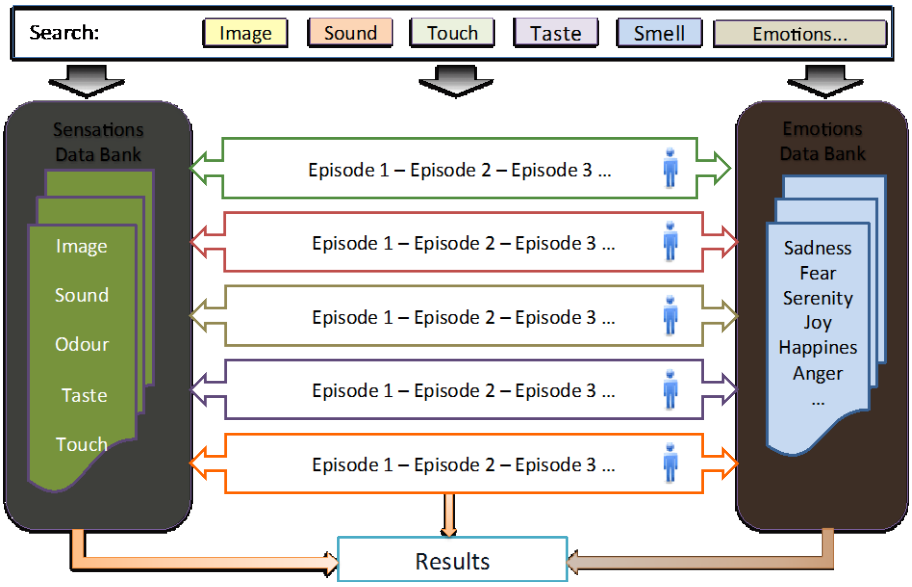

Fig. 6. Framework based on the Five Senses and Emotions

The framework then provides the possibility of searching for the different components of emotions and sensations. The stored contents can also be linked as episodes for each person or exist in atomic format. As with other search engines, the ontology learns with the effectiveness of the searches performed by users in a process of validation and reinforcement.

A template will be the basis of information retrieval and identification and can operate in background by searching for complementary information. At this stage the framework seeks information from the user and tries to associate as much sensorial and emotional information as possible in order to draw a path towards sensorial and emotional knowledge base. In parallel to the search and retrieve events, and as result of that operationalization of the framework results a database of sensorial and emotional information collected and stored for future usage with other objects.

In order to establish a path towards the usage of this framework it is necessary to be able to collect information and then to manage that information according to the model in Fig. 6. These days it is possible to have devices to collect information for personal use or to upload them for specific services on the Internet.

In what regards to sensorial information, the type of devices we use to collect information that are applicable to the framework purposes are photo and movie cameras and also voice recording devices and cell phones. Moreover some new experiments will allow collection of emotional information, as wearable computers that collect physiological measures being those; galvanic skin response, heart rate and temperature [15] this along with studies on recognizing emotions from facial expressions [16]. Plutchik's wheel in Figure 7, represents families of Emotions and it is one of the possible sets that can be used on Ontologies for Emotions.

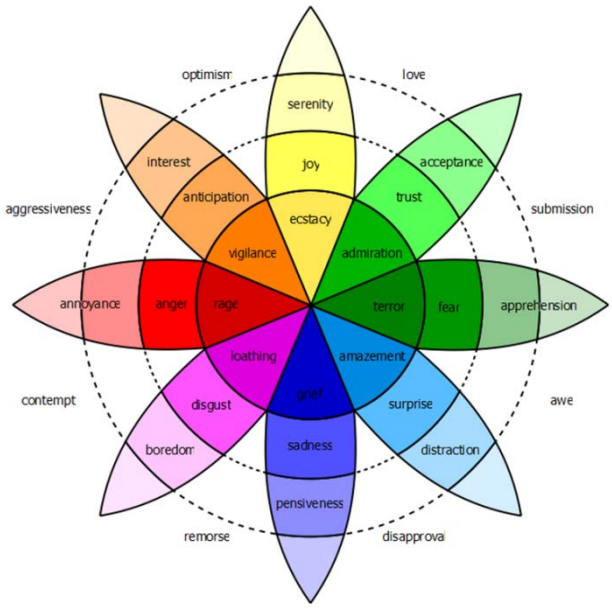

Fig. 7. – Plutchik three-dimensional Circumplex model

In order to use the framework it is necessary to address the question with the technology we have today is to identify emotions with such detail, as Plutchik and others describe, would require many other parameters as blood chemistry, brain activity, neurotransmitters and many other modalities, however recent studies are making significant progress identifying emotions without those specificities [17].

6. Information gathering supported by IoT concepts

The Internet of Things (IoT) concept comes from the notion that today computers, and therefore the Internet, are almost wholly dependent on human beings for information but people have limited time, attention and accuracy, all of which means they are not very good at capturing data about things in the real world [18].

In general terms, Internet of Things proposes an environment littered with communicating objects, with a pervasive presence around us of a variety of things, or objects, such as Radio-Frequency Identification (RFID), tags, sensors, actuators, mobile phones, etc. These networked objects will be visible in both working and domestic fields, with possible scenarios in domotics, assisted living, e-health and enhanced learning as possible examples of this new paradigm with a leading role in a near future. [19].

In order to assist in daily tasks, mobile applications try to acquire most information about a person will be supported, typically, by portable devices. Interesting concepts like smart clothing [20], wearable computers or sensorial applications for mobile phones can be of interest to gather information enriching a person's I-Episodes.

Also with the development of cyber-physical systems (CPS) result a new range of possibilities to interact with the physical world around us [21] where it is possible to collect information that could be available in the environment and not just generated by the subject. This could be one of the interesting issues to explore by enabling data gathering by, for example, a city's measuring devices for temperature, humidity, etc.

Thus in order to advance mobile data acquisition one step ahead, we propose that computational resources meet our biological perception of the world by considering our sensorial capabilities and being able to retrieve and manage all that sensorial information. That means to collect data from our own along with what can be deployed by possible external IoT services.

In a simplified view we could consider that a webpage with climatic data of one place is, in a certain why, an indirect measure of IoT devices in town, those would be for instance, an hygrometer and a thermometer that communicate readings to some service in town hall that publish them on the web.

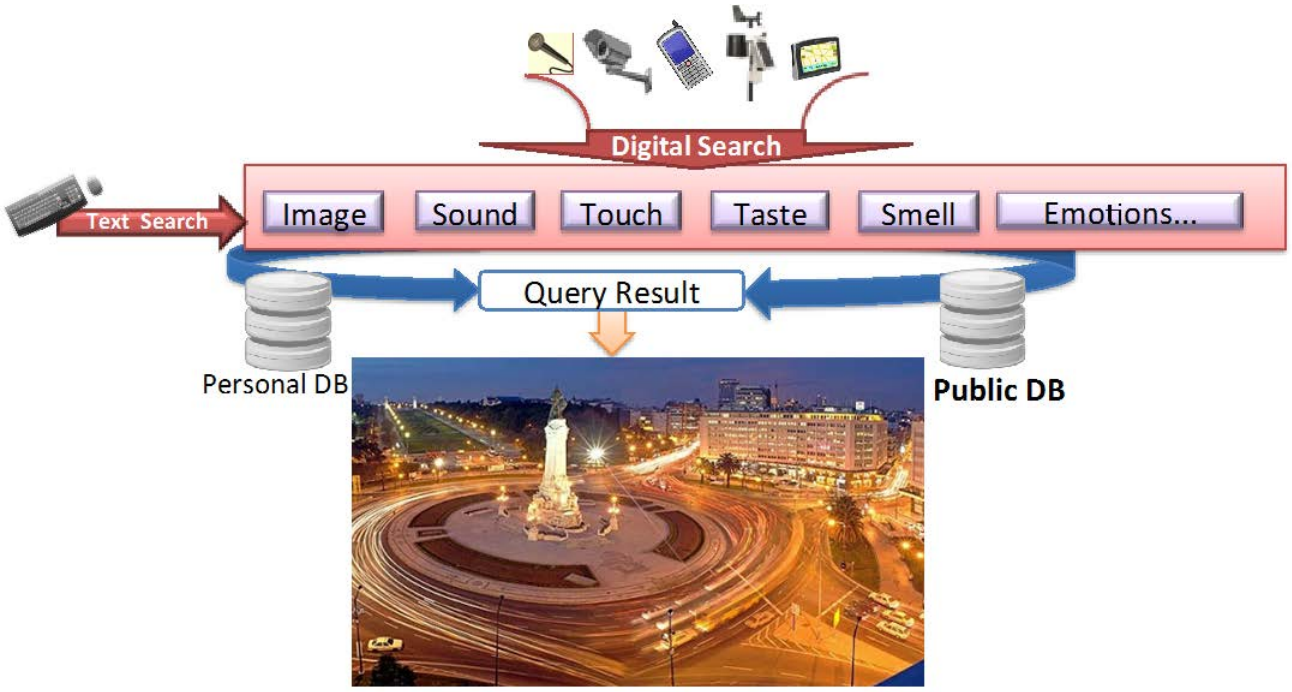

Fig. 8. Automated capture of sensorial information

The proposed view is partly futuristic but that does not imply a long time before it is feasible neither implies that partly it can be done. In fact the futuristic issues here are related to the fact that entities collect information and do not make it available in place, they filter information and sometimes publish partly or average measures per unit of time, sometimes per day or month.

The major challenge would be to retrieve emotional information as that depends on portable measuring devices that are not readily available on our mobile equipment, even thought some mobile phones already capture some measures like the heart rate. Again, as mention in last section there is the emotions issue that although Human emotions have been subject of study, with different approaches by different researchers it was possible to determine in 1981, at least one hundred different definitions [22], with a varying number of definitions by the same author. Then in order to become able to represent emotions on the Internet it is necessary to follow a pragmatic approach.

It would be important to know how many emotions are there. Scherer submits that there is currently no answer to that question [23]. The framework will address that question with the flexibility in the ontology definition in order to cope with further changes in the number of emotions and, taking the advances in technology, to handle new digitally detected emotions.

7. Conclusions and Future Work

The research work carried so far demonstrates the ability to promote the interoperability between people and computer systems, including the Internet environment. For that goal to be achieved it is necessary to converge to similar ways of retrieving and managing information as humans do and has it can be learned from the brain and from our neurophysiology.

That is the highlighted innovation from the proposed framework. Also an important finding is that, in order to understand at what lever we want to interoperate persons and systems, it is important to be able to proceed knowing the existing differences raised by the differences in “hardware” and also by different strategies in managing knowledge.

Regarding that perspective, it is noticeable that hardware compatibility is not an option in the next times, as humans will not become digital and will not integrate chips, in the same way computers will not have cells

or nervous system. That leaves us with software, services and in particular, frameworks to handle whatever approach we design.

It is important to notice, however, that developments in Human Computer Interface will promote a better relation between both systems and that could be improved with usage of devices to mediate the interaction, those could be sensors and actuators at device level. Regarding systems level it is important to converge to semantic models that will enable information that can be interpreted and managed both by humans and systems [24].

The resulting framework establishes an advance by deploying a new data model that can be used at the Internet to deal with human physiological measurements and with human centric information clusters. It will foster ground for cope with the information deployed by devices being developed and by the expression of humans regarding emotions and sensations.

As future work, it is foreseen the adaptation of the current framework for selected business, as is the case of the food industry where with the appropriated devices, as some that prototypes that already exist [25], industry can better reach costumers. This would also be extendible to the perfume industry case there is the ability to generate dozens of scents as it is the case for this business.

The authors also consider the benefit of an enriched sensorial experience for disabled people, while navigating the Internet, as is the case for persons with visual disabilities with the opportunity to experience other sensorial experiences.

Finally, the entertainment industry, either for movies or gaming, would benefit with such enriched immersive environments based on emotional data gathering along with sensorial enriched experience, reaching the brain in many ways and completing the sensorial experience towards human nature.

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