IdeaGarden: real-time documentation of meetings by capturing and composing digital & physical information as photons

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ABSTRACT
Creative activities such as brainstorming, discussions or even presentations in small groups are difficult to document and reflect on in real-time. Many mediums are used to express and iterate ideas and concepts, ranging from physical sketches, objects and embodied demonstrations to digital artifacts such as computer based documents. Networked resources and actors through mediated communication systems like videoconferencing and server based repositories and services, create a complex hybrid ecology of services, devices and content. The question remains how to integrate all these items of such diverse nature? In this paper we describe the IdeaGarden system, a hybrid environment that allows users to capture, transform and share ideas by creating visual compositions blending photons, bits and atoms. The IdeaGarden uses wireless, at-hand cameras and video-projectors in order to capture and display concepts and ideas in physical and digital space in real-time so they can not only be archived but also modified, by successive compositions and re-compositions. We then examine how the IdeaGarden allows associative cognition, instant tagging and how this leads to the creation of an external collaborative memory shared by users during and after meetings.

Author Keywords
Computer Supported Collaborative Work, Creativity, Tangible User Interface, Documentation, Brainstorming, Hypertext.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Even though computer-based work constitutes a main part of today's occupation in work environment, a large majority of creative activities still happen in the physical world, in small groups in a conference room, often equipped with a video-projector and a whiteboard. The configuration is often one speaker addressing an audience equipped with laptops, or many small groups working together and then gather to present their ideas to the group. In addition, people often attend these situations with notebooks, paper at hand, or other physical objects that allow them to externalize their ideas while documenting them.This diversity of practice is important because it allows every person to express their unique concepts and thoughts with skills in which they are more comfortable or gifted to communicate. Each person's style of communication and cognition is reflected in the tools used, usually mixing both physical and digital media.

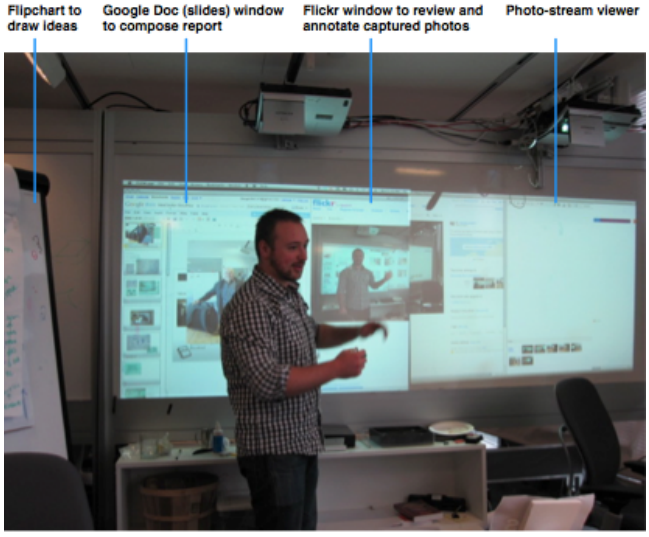

Fig1: IdeaGarden environment

However, the heterogeneous nature of these practices makes these tasks difficult to systematize in a shared computational environment. Moreover, going from digital to the physical world is usually an asynchronous and slow process, involving usually printing or sharing information after the fact. Therefore, we identify two main challenges for reflecting on creative activities in work environments such as presentations, brainstorming or meetings.

Documentation is tedious and often done after the fact (post-brainstorm, asynchronous), usually by one or two person, not by the group. Creative people use indeed a

variety of mediums to express their ideas very rapidly, it is not easy to capture in real-time an enormous amount of information with traditional techniques such as note taking on a computer. In addition, when describing a physical prototype or a sketch on a post-it note, not only leads to ambiguous interpretations but also cuts the idea from its original locus and cognitive context in tasks usually led by free association or systematic exploration of a design space.

At any given time only a few people are actively documenting, usually by taking some notes and taking some pictures that will be then shared with the group by email, in a wiki or through a blog. It is a challenge in small social activities where most of the time the audience is passive, listening to one person speaking. Moreover, it is important to distinguish how the reception of ideas (assimilation) is different from the actual understanding of them through sketching, note-taking, dialogue (accommodation). Being busy listening and re-enacting ideas, it is difficult for users to make sense of new concepts while documenting and sharing them. In order to address these two challenges, we believe that we need new tools for presentation, documentation and sharing of ideas, in real-time and respecting the heterogeneous nature of creative production.

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RELATED WORKS

WhiteBoards documentation systems in CSCW, Ubiquitous environments

With the development of personal workstations and the relative availability of low cost projector-camera systems, many research groups created rooms with desks equipped with monitors and walls with whiteboards filmed by camera and for some with the possibility of video-projection. Xerox Parc pioneering works in augmenting groupware with integration of element from the real world initiated a long series of great projects like Colab [7], Digital Desk [8], Ariel [9], LiveBoard [10], VideoWhiteboard [11] and more recently BrightBoard [12], Collaborage [13] or ReBoard [14]. These systems propose many variation of how users can capture, segment and even re-project information from and to (augmented reality) the physical world in a digital context. In general though, also these systems use cameras (or actuated cameras), they are usually fixed and oblige the users to operate it from a specific location and in general with constraints kind of medium either dry-erase ink, paper or digital ink. In the context of creative process documentation, we think that an appropriate system should be able in theory to be content agnostic and allow user to digitize any kind of medium.

The CSCW (computer-supported cooperative work) and the telepresence/mediaspace research communities also provided many systems to capture creative informations by digitizing sketches, notes, from horizontal or vertical surfaces. Ishii's TeamWorkstation [15], Clearboard [16] and later MetaDesk [17] tangible Interfaces allowed user to capture and manipulate information from the physical to the digital world. Environments like the iRoom [18] thought about the integration of multiple device into the system such as post-its, laptops, and allowed users of a space to gather the information created in space into a web server accessible by remote users (synchronous) or by users from the space at a later date (asynchronous).

These research projects explored in depth how to digitize and share information in a small group of users, however, many of these systems were not specifically designed to interact with global networks such as internet clouds or heterogenous networked information systems composed of machines and objects. With the ubiquitous development of the Web and later of fast internet connection leading to dense infrastructure for collaboration, many researchers later investigated how these collaborative systems could be structured from the beginning as an hybrid hyper-networks.

Augmented reality multi-surface environments

In the last few years, in the continuity of the famous Digital Desk of Pierre Wellner [31], many systems were proposed to capture and reuse physical and digital informations in augmented reality contexts, using projectors and cameras to track objects and gestures. However, in most of these systems the cameras are wired and fixed (DigiPost [24] , Diamond's Edge [25], Pictionaire [26], DocuDesk [27] and Designer's outpost [28]). Fewer systems like «Where the wild things work» [29] allow user to upload pictures from digital cameras but do not base their all system on a mobile point of recording. The digital camera and mobile phone were only an additional source of data, most of the interaction and recording happening through the fixed elements attached to walls and ceiling.

We believe that the mobility of the image recording is a key factor for capturing systems since it allow users to capture items that they would never have kept with other systems (such as digital pen and pre-defined recording areas). We take this hypothesis from developmental robotics where researchers have shown that the difference between systems with fixed point-of-view and those with movable (actuated or mobile) attention span is a key factor in the possibility for actors (humans and machines) to «co-ordinate» actions through shared representations, even though they do not share a language (learning without language, Steels and al [30]). Our starting point for the design of the system was to let any user of a space be able to record documents such as sketches on paper, physical objects in volume, screens of computers, but also people in the room, gestures, or even birds or planes hovering on top of the campus if they want to.

In addition, the above systems did not put an emphasis on rapid-cycling between capture and reuse of information, the fastest of them operating in minutes not seconds, another design point that was very important to us since we think that like in a conversation between people, physical and digital representations should be able to be modified at the speed of thought, ideally in milliseconds but since it is not possible with today's network infrastructure, in seconds.

Our goal is not to archive everything to let user browse through it to recollect information and knowledge weeks after, but on the contrary to let them loop rapidly through Read/Write phases, a bit like architects or designers do when they sketch collaboratively or as jazz players do when they improvise. The new challenge here is to open these systems to be able to allow any arbitrary piece of information whether immaterial (ideas), artifacts (physical objects) and virtual elements in real-time, or as fast as possible, to try to fit into the cognitivo-motor loop.

IDEAGARDEN

System Description

The IdeaGarden system bridges physical and digital space through hybrid environments open to visual interfacing and indexation of content. The system captures all forms of expressions with a camera, tethered to the ideation space. The camera is a standard Canon retail digital camera, which we selected due to its ease of use and rapid start-up time. Users capture pictures of sketches on notebooks and whiteboards, gestures, screen shots, physical objects or people interacting with the physical space. The camera is literally tethered to the space with a cord that recharges it and also prevent it to disappear, being always «at hand». The captured pictures immediately upload automatically to the "Flow server", through the Eye-Fi SD Card connected over Wi-Fi to our server. The Flow-server's function is two-fold:

- Acts as a gateway to the ecology of services utilized by IdeaGarden, such as Flickr (Online photo service) and Evernote (shared documentation service). The server side code was designed such that any XML interpretable API can join the ecology.
- Presents the picture feed as an RSS stream to all the ecology of services and to the I/O server

The I/O server role is local: it receives the photo stream from the camera and redistributes it to the physical space, through connected projectors. We optimized the system, so the time delay between taking a picture and it reappearing in a projection, is on average 10 seconds.

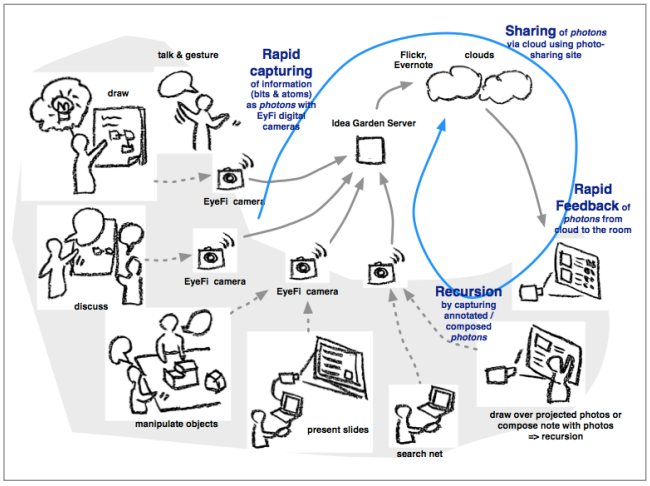

Fig 2: System schematics

Re-projection of these pictures on different parts of the space like white boards, notebooks or the physical objects themselves, creates a composition, where physical ink and digital pixels are at the same hierarchical level. The I/O server can be accessed by any JavaScript enabled web browser through our a web app called Flow, which enables users to interact with the photo stream and with the projections around them.

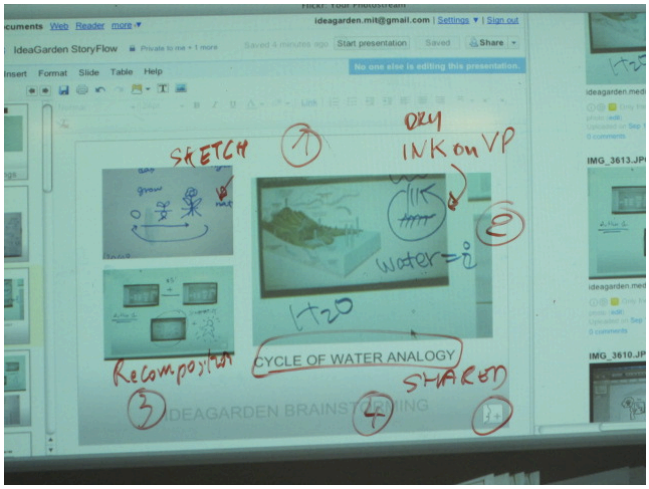

Fig 3: Composition/Recomposition

An example workflow, could be imagined:

- A user walks up to the whiteboard and sketches a figure
- A collaborator takes a picture of the sketch and the hand of the person sketching
- The sketch reappears on the whiteboard, so the sketch can be erased or modified

Another user can take a picture of this composition of two sketches and can access it on its computer and annotate it digitally, adding another composition on an existing one, creating a recomposition.

Curation

The ease of the above described workflow enables a powerful process to capture ideas, but also creates a problem of curation, since massive amounts of data can accumulate rapidly. In order to allow these images for further retrieval by users in a subsequent meeting or brainstorming IdeaGarden integrates text and images as metadata in order to tag selected documents as interesting. Three different techniques are used to add information to pictures: highlight, tag, flag. The first one relies on the counting of clicks on items in the stream of picture to differentiate some of the salient ones in a massive amount of visual documents that are generated by the system. Tagging is used to add semantic information to pictures for later retrieval or aggregation of meaning from the content. The last one, Flagging, consists in explicitly mark a picture with a social tag that correspond to a user or a social object such as a non-living networked physical entity (objects, physical tag, or even a picture).

These different levels of marking the media generated by the system allows users to navigate through their

collectively crafted memory from multiple dimensions and perspective. Having a million picture is almost like having none if there are no appropriate way to parse this massive amount of documents into an appropriate level of meaning, reducing complexity to an operational synthesis. Like in multi-scale or zoomable user interface, the IdeaGarden proposes to its users to first access previously capture content from a simple narrative or few selected pictures and then unfold more through the rich structure of concepts and ideas that were in the context of these items when they were created. Users can add metadata and relevant contextual information to images in the stream which are then synchronized with the IdeaGarden server through callbacks to these services. Furthermore users can also physically tag their compositions using tags attached to physical objects, which are recognized by machine vision, supported by ARToolkit.These tags can be used for retrieval as well.

Note that in contrast to systems that provide continuous archiving of the space via video and require post-hoc annotation, the IdeaGarden proposes to delegates the segmentation of activity documentation to people present in the room, actively relying on their point-of-view, judgement and unique situated perspective on the moment. Because it is not as easy as recording everything, it also brings value to the retained pictures of the sessions, since they required an effort or focus of the person that took them. For instance, after 12 months of using the system, we only have 3500 pictures, to put in contrast with hours long recordings to be annotated if we had decided to use video. We believe that this kind of man-machine cooperation is very powerful, and maybe as smart as the environment that record everything and auto-index content according to computational schemes.

Technical Description

Hardware

The IdeaGarden system uses a set of wireless mobile and fixed wireless camera physically attached to the space, always ready to be used to document content or conversation happening in the space. The users can also use their mobile phone as camera by using specific applications that allow streaming of pictures over WiFi. It is very important that these cameras are “at hand”, accessible very rapidly by users to document an item, in the same way that they would access a pen to sketch an idea. They are then always on, and accessible from their physical case but also for the fixed one through a web application called Flow, where users can take pictures of things in the space by pressing a button on their browser. This function works also at a distance, allowing remote participants of a meeting to share the document process from afar. The system uses many ultra short-throw video-projectors situated close to whiteboards, our main meeting table and on paperboards, covering more than half the total physical space. The I/O server is connected to these projectors and allow users to interact with captured content through a client integrating the stream of compositions, through a web app called Flow accessible on any Javascript enabled web browser (including mobile phones and tablets) and through more advanced yet classic HCI techniques such as multi-touch and gestural interaction on the whiteboard, pick-and-drop and mixed-reality manipulation of pictures by using physical tags in front of whiteboards or laptop equipped with a camera.

Web Interface

We developed a browser-based environment that displays in real-time the pictures taken by wifi cameras (5seconds between pressing the button and available on the page). This web based interface is available to users with laptops, but also displayed on the paperboards and whiteboards by video-projectors so that everybody in the room can modify them by adding either digital information (with cameras, a web-browser) or physical (by writing directly on boards). Taking a picture with a wifi camera allows to create compositions and re-compositions of ink and photons, physical and digital blends that the systems archives and updates visually in the bottom-left part of the interface called the river. On the top left, a rich Html window allow users to compose a small story by arranging pictures, text and hyperlinks.

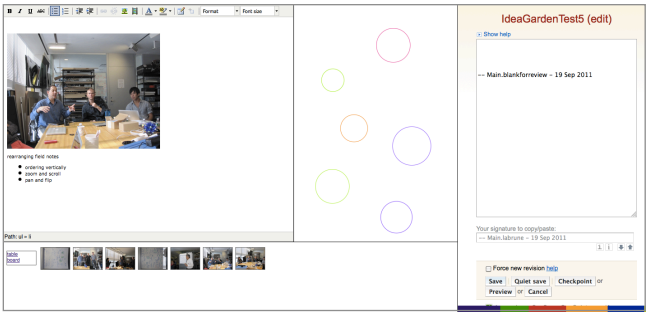

Fig 4: Flow Web Interface

On the right side, a pane allows users to drag and drop their small html story snippets into the wiki of our lab or in any web based collaborative tool (since we use different ones depending on the context). In the center of the interface, users can click and create colored circles to highlight physical objects under the reach of the video-projectors. Because all these tools are web based, different users can interact in real time, inviting to an interesting division of labour, cognitively and practically. For instance, somebody sketching on the board can ask somebody else to type something or to take a picture of something else, and then rapidly add information to it on the board, the final composition being recorded by the system and added to the global narrative of the session.

Software Client Interface

Another component of the system is a client application called Flow.app that let laptop users to display a triptych container filled with a cloud-based collaborative live editing tool on the left , a central piece with a private wiki such as the one of our lab, and on the right a MediaRSS stream of pictures taken in the space by the users. By drag-and-dropping pictures between panes, each users can create a little story bit in real time and select, tag or highlight a picture and put it in a sequence that explain a particular concept, idea or representation captured in seconds by the systems.

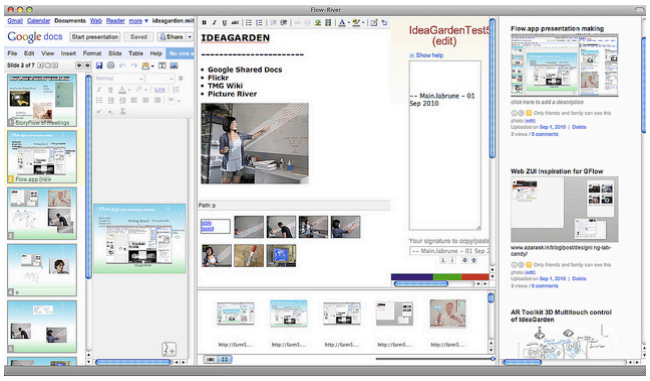

Fig 5: Flow.app

In this picture above we see how this whiteboard wall displays (via Flow.app) on the left a picture taken from a sketch book on the table on top of which some sketches where added to complete the schematics. On the right, a local java application displays a picture of this composition that contains a the sketch, ink annotations and metadata added by people through their browser, in the room and also from a distance since there were remote participant to this brainstorming.

CASE STUDY

We conducted an informal empirical study of the IdeaGarden system for 12 months, involving different creative teams ranging from 10 to 20 people using frequently the space in presence and also connecting to it from afar. On average we collected 500 pictures per month that were tagged, shared in the cloud and that circulated in the physical space. We isolated three specific activities that were remarkable and present here some insights we had by going through this reconstructed memory of the space.

Presentation

A typical activity consists in one or few persons presenting a document or a slideshow on the whiteboard and thinking aloud with seated participants in the room. In this context, we observed that people that use laptops and sketchbooks are very keen on providing information as a back channel (not to disturb the orator) and take picture either of screen (for related content, with URLs), items they sketch on the fly on their notebook and also participate in the highlighting and tagging of picture in the river of the IdeaGarden through the Flow.app client or directly through a web browser. In this activity, the division of labour and the proximity of a physical camera on a table allow users for *discrete* interaction with the system and turn their passive, lurking attitude of patient listener into a subtly more active role of documentation of the presentation, creating together a stream of related concepts, ideas, that were trigger by particular topics discussed by the presenter. In addition, this situation proved to be ideal for composing short sequences of pictures, usually accompanied with small narratives that relates what is seen visually.

Existing research-grade documentation systems focus on archiving as much information as possible, usually through hours long video recording of people presenting or by capturing digital presentation content, making retrieval a challenging since these processes create massive amount of data. In most of the sessions we studied, the participants would use the system to select only relevant information (some sketches, ideas, people involved in the conversation) and create a short narrative with these items. We asked them why they were taking a picture of these things and generally people did not know the exact reason or could not indicate why it was relevant to them, they just felt like it or were asked by somebody else to. In a way, they were not collecting content meaningfully but more intuitively.

This unexpected observation is intriguing to us and leads us to think that in addition to persistent recording and meaningful (symbolic) annotation of activities, another kind of segmentation of these meetings can be relevant, based on the way people think information is salient, without being necessarily categorizable into semantic categories. In this respect, these observations confirm what Steels and al [30] have shown about pre-symbolic shared representations between actors: coordinating between actors does not always require abstract or symbolic categorization, other kind of markers (asymbolic, presymbolic) might help people to organize knowledge in order to understand it later, in a different context. This also confirms how collective activities not only split mechanically tasks but also cognitively, one person explaining an idea might understand it better once another person will reframe or represent it in a different way afterwards.

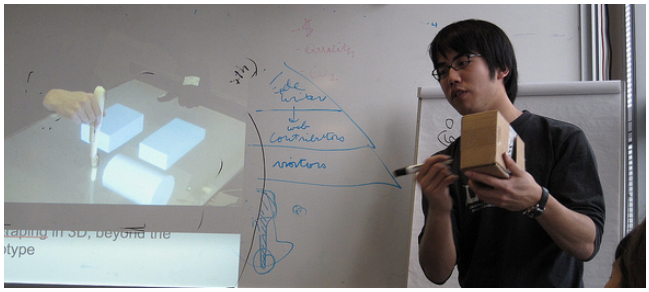

Fig 6: Presentation capture including mixed media

Brainstorming

In fast pace or deep-dive creative activities such as brainstorming or body-storming, there is usually not one leading person, the topology being more diversified and encouraging picking-up on the idea of other to continue them or make them more caricatural, extremes or reverse their meaning, parody them. By using fix and mobile cameras in the space, many users document the process as it unfolds (not after the fact as it is often the case) and can move easily content from one surface to the other to create compositions, mixed assembly of content drawn on sketchbooks, tables, or any appropriate medium. In this example for instance, a research paper is associated with hand-drawn sketches and physical tagging devices. This picture tells a simple story with mixed media, and might help to remember this concept for the next brainstorming. Note the cable of the physically attached to the table camera, always at hand and powered for rapid capture.

Because of its high throughput and speed of capture, the IdeaGarden allows on-the-fly organization and editing of

relevant information, helping participants to make sense of their documentation in a moment of these concepts are still present in their mind, not after the fact like in many tagging or semantic networks application.

By insisting of documenting these items as they are created, we might also change the course of the brainstorming by creating relevant compositions that will be later recursively re-injected into the stream of idea, like in our original water metaphor. In many brainstorming sessions held in the Idea Garden environment, we observed that participants that were new to the system quickly understand how to use it since it only requires to use a physical digital camera attached to the table and to type a URL in their web browser to go to the flow interface landing page dedicated to the activity of the day.

This simplicity allowed participants to delegate picture taking to different people in the room, allowing different style of framing and also different point of view of what was recorded. In addition to the usual post-its and sketches collections, some participants would mime their creations or take pictures of small models created with rapid prototyping techniques.

Fig 7: People showing a concept

Because the camera allows to take a picture of people, it was frequent that people would 'pose' close to their ideas and creations, an interesting point related to the authorship and context of creation of ideas. Many sessions were held with remote participants via videoconference.The attendees proposed ideas but also modified the one presented by their peers very fast since they could access them in real time on the flow web interface. These concepts were then recomposed by their remote peers by adding ink or photons on them, a bit like in a visual 'exquisite corpse'. Although these features exists in digital tools, we were amazed to see how the flexibility of the system to capture all kind of items very rapidly increased the pace not only of divergence towards new ideas but also of convergence and selection of interesting ideas for the group.

The ability to collaboratively select relevant information and compose a good-enough short narrative of the brainstorming was very much appreciated by the participants who could then leave the session with fewer but richer information.

Also, the fact that the system will not archive all the ideas but especially the one selected by the group was a key point in the sharing of the results of the creative activity, many participants highlighted that they distributed their results because the final format (a short html story) was very convenient for them to send by email or to put in a document directly, without going to a specific interface or software.

Co-Authoring

Many programmers, authors of papers code, or write complex documents together. We found that the IdeaGarden was used by many researchers to create collaboratively documents and search for references on topics related to these papers. Because the Flow.app allows to compose simple domain specific stories and that the system can also display free association pictures from web data banks or from the IdeaGarden history, users would frequently come to look together for references or structure outlines with the system since it provides many dimensions in which they felt comfortable do discuss and create together complex documents synthesized as simple narratives that they used throughout their different meetings. Co-authors also frequently displayed papers on whiteboards and would create mind-maps like sketches with dry-erase pens and linked them with pictures or other papers from related topics and then create pictures of these composition for later reuse or remembrance. As it was pointed by many previous research in the field, the ability to use white board and surfaces as temporary knowledge mechanisms was also observed in our study where many users would refuse to take a picture if some things would not be removed first, whether with an eraser or by hiding some parts with hands, emphasizing the fact that the physical world is very plastic and malleable when it comes to *remove* content, not just create and capture it. Our observations of researchers and scientists using the system manifested how much creating rapidly a visual representation of a concept is important for people to be check that they are talking about the same thing or referring to the same context.

Because of it's mobile camera system, incorporating formulas from scientific or proprietary software directly by taking picture of them from the screen or from machine screens was actually very efficient. We were surprised to see how much every scientist insists on using its own tool, very often a very unique one adapted to the task. To go from digital to photons to digital again was in this context very efficient since lots of these machines do not provide simple way to connect to their data format or output. Of course, there is noise in the image capture, but for the sake of the discussion and documentation, this was in most cases very much enough when not even very good. In addition, the ability to then add very rapidly other layers of informations on top of code or statistical graphs allowed interdisciplinary teams to create together many shared representations (for example biologists working with engineers and designers) and then converge to a common one that would be the take-away for the session.

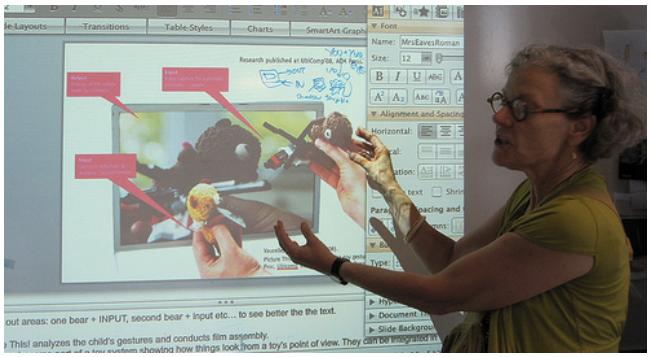

Fig 8: Co-authoring a paper

DISCUSSION

Creative transformation of real-time information

More than mere calculator, the first computers were dreamt as machines that can accompany humans in their cognitive processes [1]. In the sixties, the head of IPTO (information processing techniques office) of ARPA hired J.C.R Licklider to extend to time sharing computers some research experimented in the SAGE project, a real-time, semi-automatic military distributed information system. In addition to propose a vision of the "intergalactic network" , he examined the role of computers in the future for cognition and collective creativity. He described notably in 1960 how computers might participate in formulative and real-time thinking [2]. Licklider vision focused on man and machine achieving a symbiotic relationship, where they cooperate and join their skills (decision-making, intuition vs automation, precision, repeatability). Moreover, after explaining how physical ideation is crucial ("Nowhere, to my knowledge, however, is there anything approaching the flexibility and convenience of the pencil and doodle pad or the chalk and blackboard used by men in technical discussion"), he described how desk-surface and computer-posted wall displays might help going towards this goal. However, Licklider visionary work was only a description of a system, it allowed him only to create and fund the research space needed to implement his ideas.

The NLS (oN-Line System) [3] created by Douglas C. Engelbart and his team at SRI (notably David Evans and Jeff Rulifson) was one of these first fully functional system for collocated and distributed articulation of ideas. The NLS itself is based on many original concepts developed by Englebart for he Air Force office of scientific research, motivated to fund his research after reading a report entitled "augmenting human intellect" [4]. In this long vision paper, inspired by both J.C.R Licklider and Vannevar Bush [5] visions of the future, he describes how a creative professional (an architect in his example) might externalize his ideas to a computational system and not only document them, but also symbolically transform them, to better plan, organize and study his own artifacts. The NLS not only envision these possibilities but created actual software system to support "associative-linking" between a thought and a digital representation of an instance of it.

One of this was called Journal [6] and is maybe the first implementation of what would be called a wiki today, a real time concurrent versioning system. In this application, every information was recorded (as text) in its own context of creation (for later re-investigation) and assigned a unique identifier (called IDENT code) to be retrieve later but also instantly being linked with existing content in the system, leading each user towards the creation of what Engelbart named an "augmented knowledge workshop" [4]. Being in an environment of computer programmers, engineers and operational strategists, the Journal was operated through a programmable interface, based on text and algorithms. This powerful mechanism for logical thinkers was very efficient in the context of text based creative processes, but somehow far from the intuitive and serendipitous creative sketching abilities of an architect, as described in the vision few years before.

As a continuation of the works initiated at Engelbart's ARC (Augmentation Research Center), many researchers, especially in the Silicon Valley, then started to address the challenge of incorporating non-textual information in real-time symbolic documentation system.

From Hypertext and the Web to the Cloud and networked information systems.

Based on the visionary concepts of pioneers like Ted Nelson Xanadu [19], many researchers started to create software-based hypertexts like Hypercard [20] in the eighties. Collaborative and non hierarchical environments such as hyper-structures are very relevant to creative activities where ideas are not necessarily expressed in a specific order or structure from the beginning. Later, the Mosaic [21] browser and the idea for the Web were based on researchers in hypertext started by Tim Berners-Lee during the same period during which networking personal content was a now possible through the widespread adoption of modems and lightweight networks.

Like David Evans and Doug Engelbart Journal application [6] , Mosaic was first developed as a Read/Write system, allowing not only to display content but also to modify it on the spot, directly reconfiguring or iterating on a page from the client that will then update it to the server. This notion disappeared and was later revived in systems like wiki, however, few research systems allowed users to read and write content in a coupled manner on physical and digitally connected spaces.

More recently, many commercial systems like Evernote [22] or Flickr [23] allowed users to document their activities with mixed media, usually pictures, text or documents and more rarely integrate physical objects as digital hubs. The multiplication of tools to document activities is as big as the many ways each creative individual expresses himself ; leading to an ever-growing ecology of devices, interconnected through many APIs (advanced programming interface) integrating many streams of content together.

Rapid Read/Write environments with Photons, Bits and Atoms

We believe that systems that are based on the universal nature of photons in addition to bits and atoms, might allow their users to link more easily disparate content from

different sources, media, either physical, digital or hybrid as compositions and recompositions. In addition, the ability to distinguish different roles in the live documentation of creative process may lead to the construction of multi scale narratives or short story of innovative activities for later reuse, reconfiguration from a collaborative point-of-view, creating a shared memory, accessible by any users of a group to re-enact a moment or simply use some remarkable entities as the starting point for a new conceptual research.

Digital worlds are ruled by languages that are very different, as are the personalities of the designers of software. In the physical world, there are some universals that come from physics, like persistence of ink on paper, weight of the pen because of gravity, etc. It is then fairly easy for humans to integrate different kind of physical elements as a narrative, especially when most of them are visible. Capturing pictures then make a lot of sense in this respect, especially when these pictures can also integrate additional informations coming from computers, which also use luminous pixels to interface with humans.

We envision an augmented reality environment using mobile and fixed cameras and projectors, computers and traditional paper, whiteboards, tables and other physical ideation media that could be seamlessly and intuitively linked by users. Although many previous research systems asked the users to specifically change their practices and use dedicated hybrid pens, interactive tables or whiteboard, we think on the contrary that they should express their ideas through the medium that best fit their expertise, message or context, not being constrained by the information system in the space they are collaborating in. Our main point compared to other systems is that we based entirely our system on mobile picture recording: not on machine ready devices but on human readable and writable environments.

In addition, our goal is to integrate the transformation, documentation and collaboration features articulated in existing research systems with three main factors that we believe are key in order to allow collaborative cognition and focus on appropriate information: the composition of information through photons, the emphasis on speed for distributed cognition and the importance of hybrid and recursive collaborative practices.

Photons, Bits and Atoms

Most of the system presented in the literature focus generally on turning physical information into digital objects (automatic classification, indexing, meeting capture). Different methods can be used to capture creative artifacts like digital pens, interactive surfaces. However, many of these systems constrain their users to operate a specific device or system to express their ideas. One person sketching usually on his own notebook will be asked to use another one because it has a pattern on it that a computational system can recognize. Another person will be constrained to write on a whiteboard when he would maybe have preferred to simply tell a story using his voice and drawing an invisible shape with his hands.

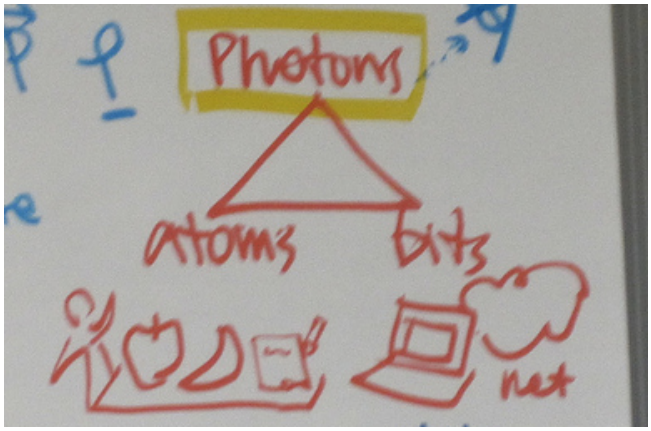

Fig 9: Photons, Bits and Atoms

Video-camera based systems can address some of these issues (openness, less-constraints in terms of tools) but create massive data streams, hours of video of meetings, that need to be then annotated through tedious and repetitive video-editing. Some systems automatically tag information based on pattern recognition and classifiers which usually works pretty well for information that can be predicted but less good with creative artifacts, that usually resist predictive ontologies by nature. There is therefore a need for a-semiotic or pre-semiotic markers. Humans are very efficient to notice what is "interesting" or "remarkable" without necessarily knowing how to categorize things with a textual reference or a concept. For these reasons, we think that picture based documentation systems are the best suited to allow a fluid circulation between the physical world and connected online virtual storage and documentation systems.

Speed and Distributed Cognition

Usually in Human-Computer Interaction, real-time interaction with computer, especially direct manipulation is possible when the sensorimotor loop, the maximum time between an input in the system (like moving the mouse) and an output (the cursor is moving on the screen) is inferior to approximatively 20 milliseconds. Similarly, we would like to introduce the notion of cognitivo-motor loop, i.e. the maximum amount of time in which an idea or a concept can be represented by a human-machine system. Like in interface design, if this amount of time is too long, it becomes very difficult to operate the environment (lag) or even impossible. One way to look at this concept is to refer to situations where you have an idea and you need a pencil *at hand* , in the next few seconds. If you do not, your idea might be less clear, or even gone. In the same way, only a short window of time let users externalize but also document a sketch, a written note or an object. The more documentation awaits, the less chance it has to happen ever. Empirically we estimate as a start that the cognitivo-motor time span ranges from few seconds to few minutes maximum. Although this is not as fast as the sensorimotor loop, it uses the fact that ideas and concepts can be memorized and acted with a bit of delay, which is less true of action with information of the body (difference between remembering body state and mental states).

Recursive Collaborative Practices

Douglas Engelbart's Bootstrapping concept popularized the notion of circular iterations for design, consisting in improving on a weekly basis not only the content created by users but also on the tools used to create. One area that was missing in his vision was linked to the recursive nature of physical space. We are interested in providing hybrid tools that can be reconfigured both physically and digitally by users of the space. For example, through the invention of a visual annotation scheme to be able to retrieve many iterations of a similar idea or concept both as a sketch in a notebook and as a digital document in the cloud.

Fig10: Recursion

In addition, division of labour is rarely addressed in the design of documentation tools, most of the features and software usually been oriented towards a single user connected to a network of people. The situation we are interested in usually involve many collaborators, with different workloads available while brainstorming, sketching, discussing. If the system allows near-real time archiving of items it lets users select, index, tag items as they create them, hence reducing the massive amount of data created by the system. Instead of having each user documenting the same story about the space, they can compose together a collaborative narrative with each piece being different for each user.

CONCLUSION

We plan to continue to use the IdeaGarden system to assist us in our creative process, and especially to help developing the system itself. We also look into new kind of physical tags to help capture and retrieve information by demonstration and the use of simple gestures to document and navigate through massive amount of data. We also plan to do more research on how to integrate different spaces together and help users to interacts in remote spaces through shared physical objects and content.

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NOTE

All the pictures and illustrations used in this article are directly taken from the IdeaGarden database without being modified, only cropped for better integration in the structure of the article.

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