Pointing in Multi-Disciplinary Medical Meetings

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Abstract

In this paper a field study of using laser-pointing during multi-disciplinary medical meetings is presented. The pointing behaviour adopted by radiologists and surgeons to communicate about and collaboratively analyse patient data such as CT images today is illustrated based on field observations of pre-operative meetings. In a field test, laser-pointers were introduced in pre-operative meetings. How the dialogue and gesturing changed compared to meetings where laser-pointers were not present were investigated. Results from our study show that the multi-disciplinary medical meetings are clearly affected by the introduction of laser-pointer devices and we believe that the participants would benefit from a future gesturing tool if it was carefully designed. The implementation of an application that provides touch feedback in three dimensions of the anatomical structure of blood vessels as well as tumours is described and related to our results.

1. Introduction

In healthcare multi-disciplinary team meetings (MDTMs) are becoming the preferred way of working. In those meetings specialists from different clinical disciplines meet and review patient cases, establish a diagnosis and disease stage, and decide on the appropriate treatment. It has been shown that these kinds of MDTMs increase patient safety [3] and improve processes and outcomes of care. This emphasises the need for the specialists to meet and discuss the patients' conditions before an operation. The surgical department observed in the study presented in this paper focus on sever diseases in the upper part of the abdomen. In the pre-operative meetings strategies are decided for next week's operations. Several types of information about patients are used as a base for the discussion at these meetings, for example CT, MRI and ultra sound images that are projected on screens. We argue that deictic references are essential in order for the participants to get a common ground regarding the patient data. Deictic references are verbal expressions such as 'this', 'that', 'here' and 'there' that often combined with gestures refer to something like an object, place or person [6]. Deictical referencing is situated and people use the immediate context, bodily actions and the interactional activity at hand as resources when referencing [9]. We have made an analysis of both MDTMs as they proceed today and meetings where we introduced laser-pointers to everyone but the radiologist who uses the mouse cursor. In this paper concrete examples will be presented that illustrate how pointing is used in MDTMs in order for people to communicate about and collaboratively analyse patient data such as CT images. Five specific pointing acts were identified. First, deictic reference to an object, e.g. pointing to a certain detail in the medical image. Second, deictic reference to an area, e.g. pointing to an area of the image by drawing a line around a number of details in the image. Third, representational gesture, e.g. showing how surgery should be performed. Forth, navigational guidance, e.g. pointing at a specific blood vessel while talking about it in order to guide the radiologist to navigate along it by scrolling the CT stack. Fifth, coordinate data retrieval, e.g. pointing in order to coordinate what details in an image the radiologist should retrieve more information about such as another type of patient data.

Results show that the surgeons and other specialists, usually not being in control of the image material, became more active when laser-pointers were introduced. They in some cases took over the dialogue concerning the patient data by pointing to the parts of the images that they wanted the radiologist to show and even specifying how. The motivation for this study was to inform design of a multimodal application that supports haptic pointing and gesturing. An application was developed concurrently with the user studies that allowed the surgeons to point at and feel (by haptic feedback) the anatomical structure of blood vessels as well as tumours. The application provides touch as well as visual feedback in three dimensions. This makes it possible to feel the 3D shape of organs and the distances between them with a haptic feedback device, as if it was a real physical model of the anatomical structure.

2. Background

Research about gestures shows that gesturing in itself is communicative and is the act of creating meaningful signs to others [6]. Grounding activities aim to provide mechanisms that enable people to establish and maintain common ground that is defined as a state of mutual understanding among conversational participants about the topic at hand [7]. Using deictical references, like "that", "this", and "there" often together with gestures, gaze or body positioning is one kind of grounding activity that direct the partner's attention to a specific object [6, 9]. Maintaining common ground is also shown to be much easier when collaborators can make use of this kind of references [2]. This is especially true when the focus of interaction is a physical object. The importance of providing the possibility for deictic referencing in collaborative environments [5, 11, 14] as well as for teaching surgery [17] has been acknowledged in a number of studies. In an analysis of radiologists' and surgeons' descriptions of patients and representations of them in the form of CT images it was shown how intricate the discussions are that precede decisions about surgery [13]. Examples are shown of how the radiologist use pointing and talking about a tumour in the grounding process about a CT image shared by the surgeons present in the meeting. In an ethnographic study of MDTMs, Kane et al. [10] show the importance of the presenters being able to point to specific areas in the medical information, as it is an essential part when presenting their statements to the other participants. During recent years haptics and audio feedback have become more important in medical applications, when it comes both to training [12] and simulation [4]. Among the most robust findings, when it comes to the role of the haptic modality in computer interfaces are that task performance and the sense of presence improves significantly when adding haptic feedback to visual interfaces [16], especially when two users are collaborating in the same interface [15].

3. User study in the clinical context

The work process at the surgical department starts with a consensus meeting with the purpose of deciding if surgery should be performed or not, followed by a pre-operative meeting held the week before the surgery where the strategy for the surgery is out-lined. In both meetings planning for future action is the main task that is performed. Furthermore, these meetings are highly formalized. A younger surgeon or the referring doctor is the presenter and begins the discussion by making a short introduction of the patient's medical material. The introduction is followed by a radiologist's presentation of the radiological diagnosis, showing images from different examinations and pointing out specific parts in the images. After that, the chair, a senior surgeon, leads the discussion and is responsible for reaching a decision or strategy at the end. Both meetings are held in the same room, equipped with a radiology workstation and video projector (Figure 1).

Figure 1. Pre-operative conference with the radiologist workstation on the left, the specialists and the patient image projection.

In the meeting room the radiologist is sitting by the radiology workstation, showing the radiology images, and using the mouse to point at specific parts of the images. The other participants face the projected radiology images with no possibility to interact with or point at the images as it is today other than gesturing in the air and/or approach the screens.

3.1. Method

The analysis is based on observations in the field and video recordings of the MDTMs. Meetings were studied during two separate periods. First, video recordings of both decision and pre-operative meetings without access to laser pointing devices were analysed. Second, laser-pointers were handed out to all participants except the radiologists in three consecutive pre-operative meetings. Participants were not given any instructions on how to use them. The three meetings were video recorded. Selected parts of the video recordings have been transcribed word by word and pointing gestures have been specifically annotated. The focus in this study is on how all participants in the meetings, including the radiologists, point at the medical information being projected on the screens. The transcribed verbal communication as well as the annotations of gestures were analysed in detail and finally coded into themes with the focus on different kinds of references made with or without laser-pointers. The most informative parts have been used as examples to illustrate our findings, together with images of the specific situations. In the result sections radiologist A is called RA and senior surgeon A is called SA and so on.

3.2. Results regarding gesturing without laser-pointers

During the meetings where laser-pointing devices were not used, several examples of different types of references were identified. When SA in the first example makes a verbal deictic reference to "a distinct tumour area", the other participants know which area she means. Later on, when SC is referring to another part of the image he points with his hand towards the image. He is interested in finding out the distance of the "engagement". In this situation pointing is merely a symbolic gesture and not very informative for the common understanding of what the surgeon is pointing at. It shows however, that other participants than the radiologist need to point at specific details in images and not only make verbal deictical references.

SA: you see a distinct tumour area in the uncinate process
RA: uncinate yes its tip or tongue
SA: yes
SB: it's clear with that localisation and not being icteric ... it means it's growing very sadly ... if you look at the vein actually this is probably more complicated than you
SC [interrupting SB]: how far is this engagement it looked rather long or [points quickly with the right hand towards the screen] 28 ... 3 cm then ... yes that's right
SB: on the vein side it's quite far there
RA: but we can't say for sure that it really grows or touches
SA: it's less than 50
RA: yes

In the dialogue in the second example SA is interested in specific information and she basically takes over the navigation of the images by guiding or rather directing RB on what to show. This has the side-effect of RB explaining more about the different parts. Towards the end of the discussion, it appears that SA has a clear view of the surgical strategy. This is an example of what we refer to as navigational guidance that is when the surgeon directs the radiologist to navigate along a specific anatomical structure. In this case it was done verbally.

SA: can you follow mesenterica superior downwards
RB: what did ... the artery or the vein?
SA: the artery
RB: ... here is the artery and ... it's pretty close to
SA: can you show it coronary ...
RB: ... here is the artery ... and it's hear actually nearby ... nearby ... but it's not entirely surrounded by tumour but there is an "increase of connective tissue" around the artery which has progressed a little since the previous investigation

In the following part, SA is explaining, by vividly pointing in the shape of an eight with his hand towards the projected images, which way he will go in order to reach the tumour in the liver and perform the surgery. Quite soon SB understands SA's strategy. This example illustrates a need for being able to do what we refer to as a representational gesture that shows how a specific surgical procedure should be performed (Figure 1).

SB: but would you leave duodenum and the head there
SA: no the reason is if I need to take truncus by its "departure" ... then I can nutrition the liver by the back of gastro duodenal ... and eh and eh then I don't want to xxx ... so if I can get a [makes an eight with his hand in the air](Figure 1).
SB: yes I agree and then you can even keep the whole duodenum
SA: exactly

This example shows a potential need to point to different parts of the CT image in order for the surgeons to explain the proposed surgical procedure to the other participants.

3.3. Results regarding gesturing with laser-pointers

In the following dialogues between the surgeons and the radiologist we illustrate a number of ways of using the laser-pointer. It is important however to take into account that it is in these examples, often not clear whether the radiologist actually sees the laser point on the projection at all times as she is usually very focused on her computer screen. But we argue that in all cases reported here, the pointing behaviours show different ways in which the surgeons need to point and the pointing is clearly visible for all the surgeons that look at the projection.

In the next example SE makes a deictic reference to a specific area verbally by saying "the sector vein" and by pointing at it with the laser beam. This is a means of getting the radiologist to navigate to more relevant information about that particular part. The following dialogue is an example of what we refer to as coordination of data retrieval.

SE: ok that is good ... can ... fine ... [starts pointing] can we just look at the relation to the sector vein here [points at an area]
RC: [scrolls] yees

An illustrating example of making a deictical reference to an area is when SE points first along one anatomical structure and then along another with the laser-pointer.

SE: There goes 7 [continuously points along a line] ... there goes 6, or [continues pointing along another line]

In the next part of the dialogue that is shown below, SE requests navigation by RC by pointing at the image with the laser-pointer. By doing this SE tries to show RC what vein she should follow by scrolling in her stack of images, while SE continuously points at the unfolding vein structure. This is an example of what we refer to as navigational guidance. However, this example shows the importance of shared awareness of pointing. RC does not appear to look at the laser-pointer at the big projection screen as she is very focused on her computer screen where SE's red spot from the laser-pointer is obviously not visible. SE, who does the pointing, is aware of this which suggests that the laser pointing in this case is mainly meaningful for the other surgeons and himself in order to understand the patient case. When designing future systems for this setting we argue that it is important to consider the essentiality of all participants seeing everyone's pointers.

SE: the front sector vein [starts pointing at an area] can, can your show that
RC: [scrolls]
SE: if you go up ... [RC keeps scrolling]
RC: now I go down [keeps scrolling]
SE: [starts pointing without saying anything, RC scrolls at the same time] it should be somewhere here [points steadily over a small area at the same time as he talks, RC [keeps scrolling slowly]
SE: [A white area can be seen where SE is pointing, RC stops scrolling] there [at the same time as he continues pointing at a specific part in the little area he pointed at earlier]
RC: there ... yes ... that one [she is pointing at an area lower than the one SE is pointing at]

In the last part of the dialogue SE illustrates his plan for how to do the operation by drawing a line, where he plan to remove a part of the liver, using the laser-pointer. This is an illustration of what we refer to as a representational gesture.

SE: It is an ok distance there [starts pointing at an area] to make a back sector resection [continues pointing along a line to show the area that can be surgically removed]

In the next example two of the surgeons are pointing simultaneously with their laser-pointers at the same time as they establish common ground regarding the different parts of the patient data. After a couple of turns RC point with her mouse cursor which verifies the surgeons' interpretation of the data:

SC: [starts pointing at the same time as he starts speaking] that is the probe or [he is pointing along a duct]
SE: it's that or [points along the duct at the same time as SC]
SC: ... that goes down there so that is the hilum or [continues pointing and more specifically where the ducts begins]
RC: yes here
SC: yes yes

This example shows that the laser-pointers eased the grounding between the surgeons and made it easier to achieve a common understanding of the image. Within a short period of time the two surgeons reached consensus without having to describe the spatial relations of the anatomical structures verbally, which often takes longer time [8].

4. The pre-operative planning application

The design and development of the pre-operative planning application have been done in parallel with the user studies, in accordance with concurrent engineering. Decisions on the functionality have been based on the previous field studies within the surgical setting as well as on observations and video recordings of the pre-operative meetings. One important decision was to focus on developing a system that could support the planning task performed in the pre-operative meetings. We are however, well aware of that the meeting situation may need to change if such a system should be adopted. Our observations showed a need for visualization and interaction with the data to improve communication between radiologists, surgeons and other specialists. The discussion in the pre-operative meeting is usually related to the location and dimension of one or several tumours in relation to blood vessels and other organs. Images demonstrated during the pre-operative meetings are contrast-enhanced computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound images. Gray-scale 2D slices are the standard way of presenting the images.

To allow for a richer visualization while leaving the radiologist with a familiar interface we developed a software solution that combined visualization of 2D slices of a CT volume with a 3D stereographic visual and haptic rendering of iso-surfaces of the same volume, as illustrated in Figure 2.

The purpose of the haptic rendering in this case is not to simulate the feeling of performing surgery, but rather to add a perceptual channel by which the dataset can be explored. In the prototype, a modified implementation of the Agus et al. [1] volume-intersection force feedback algorithm was used. A simple binary classification based on attenuation values was used to segment all voxels above the median value as "material" and below as "air". In addition to the automatic segmentation a radiologist manually segments a tumour. Due to the contrast medium injected in the blood, the vessels inside the liver can clearly be seen. A marching cubes-based iso-surface polygon mesh rendering allowed for a visual rendering of the "material" and the tumour, with a different colour. The binary classification based on the attenuation level in the images makes all voxels (after filtering) above a threshold perceivable as hard material.

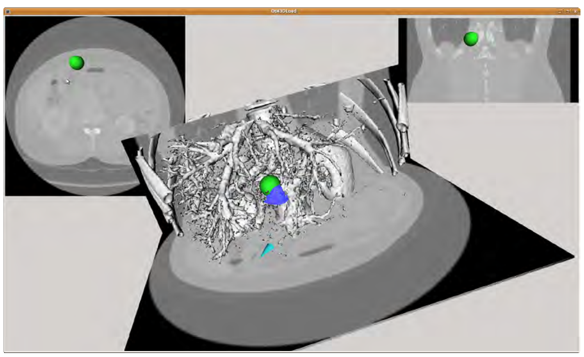

Figure 2. A 3D haptic view with blood vessels and bone structures, the tumour, a spherical haptic cursor and 2D views of CT-images.

With a haptic feedback device, the surgeon is able to feel the size and 3D shape of a pre-segmented tumour, and distances to contrast-enhanced tissues, mainly blood vessels and bone structures, in the 3D view with 3D haptic feedback. The haptic feedback is provided using a Sensable Phantom Desktop device. Three types of interactions are possible in the application. Mouse wheel scrolling up/down can be used to browse through the 2D CT image stack and the corresponding CT image slice in the volumetric haptic 3D representation. The whole 3D scene can be rotated using the mouse. Two views are linked so that the user can scroll the stack of slices in the 2D view (either horizontally or vertically) and point in it with the mouse cursor that is shown simultaneously in the 3D view as a turquoise cone along with the current slice. The position of the haptic cursor is displayed in the 3D view and can also be seen in the 2D stack. A user can in this way align the mouse cursor's position in the 2D view with the position of the haptic cursor in the 3D view. This makes it possible for the user to compare the position of for example a blood vessel in the 3D environment with the position of it in the 2D slice image. This solution provides the clinicians with both the ordinary 2D slice representation that they are accustomed to and trust, and the new 3D representation with haptic feedback of the anatomical structure.

5. Discussion

In this paper we have explored gesturing in MDTMs as they occur today without laser pointing devices and how the introduction of such devices alter the gesturing in that type of meetings. The task that the radiologists perform, demonstrating the content in a medical image that is relevant for decision-making and planning of an operation, required a lot of pointing using a mouse cursor. This was also shown in the analysis by Måseide [13] were he reports on how the radiologist "makes it visible to the audience by drawing the form of the tumour on the screen with a pointer".

In the meetings observed in this study, where the surgeons did not have laser-pointing devices, several cases of pointing and gesturing in the air with the hands were identified. One interesting example is how one surgeon shows a complex part of the surgical procedure he has in mind, in the setting without laser-pointing devices, by gesturing an eight in the air with his hand. It is clear that the others do not understand his verbal description of the procedure, so he has a clear need to show it visually in some way. These kinds of gestures were not precise and we argue that they merely indicated a need to interact with the projected information.

Results showed that frequent verbal deictic referencing together with laser-pointing occurred when these devices were provided. We refer to the gestures that the surgeons made as deictical referencing to details and areas, coordination of information retrieval, navigational guidance and representational gestures showing how a procedure was to be performed. When the surgeons had a laser-pointing device they could swiftly and precisely point at several parts after one another in the images. The laser-pointing device made it possible to point to an area of interest, while saying for example *"this must be the area where the tumour encloses the vein".* That kind of deictic reference was also made in the meetings without laser-pointers, but then only verbally. Being able to "draw" a line around the area referred to with the laser beam made it possible to talk about the patient case instead of making laborious verbal deictic references at the same time. In the meetings with laser-pointers, representational gestures showing how a surgical procedure could be performed were made. A surgeon used his laser-pointer to show how he planned where to cut in order to take out a tumour. Both in the meetings with and without laser-pointers the surgeons requested more information by the radiologist when they required specific information and asked the radiologist to scroll between the slices of a CT volume. However, when the laser-pointer was introduced the surgeons used the laser beams in such a way that they pointed at a certain spot and followed the radiologists scrolling and switching of images in order to find certain data. In one example, two surgeons pointed at the same place, with the aim of following a so-called duct. While doing this they were able to discuss the problem at hand and used the pointing as a way of grounding the focus of attention at micro level. The surgeons also used pointing for coordinating the retrieval of added information used in the meeting. They did that by referencing verbally and pointing with the laser beam at the parts of the image that they wanted the radiologist to retrieve more data about. When they did not have pointing devices this was done by verbal referencing only.

In the implemented application both the mouse-cursor and the haptic device cursor are visible in the same view. Furthermore, the 2D and the 3D views are linked and positions in them can be aligned. This application is an example of a design of a multimodal tool with the aim of providing a shared work space specifically for a pre-operative meeting that makes it easier to use grounding strategies in a more efficient way and that also provides a tactile 3D representation of information that is only represented visually in the meetings today.

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6. References

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