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TECHNICAL NOTE / *Technical*

Touchless intra-operative display for interventional radiologist

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Imaging records are an essential part of the overall management of patients due to undergo invasive interventional radiology (IR) or surgery. Imaging is needed for diagnosis, to confirm operability, plan the procedure, and as a per-operative guide [1]. In both IR and surgery, it is essential to be able to visualise and manipulate images from the workstation [2,3]. Current solutions, including the use of the PACS in operating theatres, are completely inadequate. The practice has become routine in interventional CT and the main manufacturers offer dedicated equipment to work with the imaging instrument and images [4]. The interface which offers the most is the use of a joystick to move the cursor on the screen in the same way as the conventional mouse. Manipulation, however, is imprecise and makes it slow and frustrating to use. Telecommand is easier to use but does not allow complex interactions.

In reality, once the operator is under sterile conditions, working with pre- and per-operative imaging becomes extremely limited. In complex situations, it requires a third party (loading previous imaging, MR or PET-CT displays, multi-planar reformatting, zooming in onto an area of interest, etc.) sometimes leading to loss of concentration and loss of time [5].

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Ideally, we believe that the operator in theatre should have sterile access to the image visualisation and manipulation functionalities similar to those on his/her usual image processing console. In order to meet this need, control technologies inspired from video games (kinect©, Microsoft) now appear to be mature and suitable for sterile interventional medical use [6].

To confirm this hypothesis, we have developed a hand-recognition software, linked to an interventional CT, to manipulate images from the operator's sterile workstation.

The system includes a planning interface in the CT command workstation and an additional recall screen fitted with a movement sensor in the operating theatre (Fig. 1).

Feasibility tested on ten IR procedures was 100%, each enabling the imaging findings to be displayed and manipulated in the operating theatre. The system also allowed the desired information to be obtained without using the CT system interface or a third party, and without the loss of operator sterility.

Discussion

The robustness of movement recognition systems now enables solutions with appropriate functionality for sterile IR settings. Technically, we experienced operator detection problems due to movements of the CT table and staff present in the intervention room. In order to minimise these, a sensor activation lock-out enables the operator to identify him/herself with a hand gesture to ''unlock'' the system. In addition, understanding feedback enables the operator to determine whether he/she has been correctly detected, by superimposing a green or red avatar on the screen as well as his/her hands on the image (Fig. 2). In addition, a few fine hand movement detection difficulties are directly due to the resolution limitations of the sensors, which we applaud but will need technical advances to bring in future solutions soon [7—9].

As there is a single system operator for all procedures, it was not possible to assess the learning curve and the extent to which a radiologist who has not previously used the interface adopts the system. ''Operational'' feasibility is therefore probably overestimated. During the laboratory design phase, however, we found that the system was very intuitive, mostly as a result of the choice of gestures derived from smartphones and explicit hand posture icons displayed on the screen (Fig. 1).

Overall compatibility with the situation in an IR room is good, as none of the procedures resulted in loss of operator sterility. Initially, the version designed in the laboratory responded to gestures on the operator's sides. Restricting the interaction area to the area in front of the user was probably a key factor in its feasibility.

Use of the system was compelling and there was no need to return to the previous system used. This included more complex procedures than biopsies (cementoplasty and alcoholisation) (Fig. 2). System control was robust and is therefore consistent with its use in more stressful and higher risk procedures.

The hand-recognition interface close to the patient in a sterile environment offers the operator the following advantages:

- increased independent, removing the ''pollution'' due to the third party (occasionally not of the same skill level);
- preservation of concentration (no orders to give and operator attention focused on the procedure) with no interference from a third party. Reduction of unnecessary stress;
- a gain in ergonomics, allowing the operator to move more quickly through images than with a joystick or telecommand;
- maintaining optimal sterility conditions, reducing the procedure time and risk of complications. The operator no longer needs to leave the sterile area for fine manipulation of the image, as he/she may have been used to doing [3,5,10];
- access to new functionalities: zooming in onto an area of interest, multi-planar reformatting, manual fenestration, navigating through the patient's past records with a simple searcher connected to the PACS enabling all modalities to be displayed.

Overall, the system offers greater ergonomics, greater independent, improved concentration, better sterile conditions, reduced operating time, and new functionalities.

At the time of our assessment, a literature review only found two medical publications using a contactless interface to navigate through medical images. A ''plug-in'' developed for the OsiriX open-source software, has been tested in the laboratory to assess the effectiveness of manipulating using this device [10]. The authors showed that the manipulation time was 1.5 times greater than for the touchscreen interface (mouse) in order to carry out the same procedures and that the system requires a learning time.

One surgical group has recently demonstrated the feasibility and medical utility of a contactless solution for partial kidney surgery and that the procedure time was reduced [11]. The same positive conclusions were also found mapping the mouse cursor to body movements, although this does not in our view seem to be the best solution to facilitate the interaction process.

As this is a new and as yet little used display, it does require a learning time. A hand or arm movement, however, is a more natural action than working with a mouse or keyboard. In order to become completely incorporated the display must become seamless in the environment of the operator, who is already concentrating fully on his/her hands. Gesture semantics is the key for adopting this system. The functionalities we are waiting for in software development which would enable further independence are distance measurement on an image and predicting volumes for heat ablation.

New technologies are continuing to revolutionise health. Camera and instrument miniaturisation has completely changed open surgery towards less invasive procedures such as laparoscopy. Procedures can be carried out with greater precision through robotisation [12]. Similarly, medical imaging is becoming a requirement to plan all invasive procedures in order to predict the risks of the procedure in advance. It can also be used to guide positioning of instruments