Hands-Free: a robot augmented reality teleoperation system

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***Abstract*— This electronic document is a live template. The various components of your paper [title, text, heads, etc.] are already defined on the style sheet, as illustrated by the portions given in this document.**

I. INTRODUCTION

Although advances in robot perception are increasing autonomous capabilities, the human intelligence is still considered a crucial need for unstructured environments with high uncertain or variability. Typical scenarios concern the detection of random shape objects, manipulation, or custom robot motion. Thus, human and robot should cooperate to achieve the same goal, defining the basis for the human-robot interaction (HRI) concept.

HRI can be bot physical (pHRI) or not, depending on the solution required. For instance, when the robot is constrained in a dangerous environment or must handle hazardous materials, not-pHRI is required. In this cases, robot teleoperation may be necessary. A teloperation system concerns with the exploration and exploitation of spaces which do not allow, thus, the user acts by remotely control the robot [1]. A plenty of human−machine interfaces for teleoperation are developed considering a mechanical interface, this includes exoskeleton [2] or gloves [3]. Such systems are particularly helpful to achieve bilateral teleoperation [4], where they can transmit or reflect back to the user reaction forces from the task being performed. In this case, a high perception with complete haptic feedback [5] is achieved. Other controllers includes joystick, mouse, switchbox, keyboard and touch-screen, the joystick is usually a better control device than others because the operators can identify better with the task [6]. Among the systems where bilateral teleoperation is not required, a teleoperation system is defined by mean of electromyography (EMG) signals of the muscular activity [7], [8]. However, as reminded recently in [9], EMG could be affected by difficulties in processing EMG signals for amplitude and spectral analysis, reducing their efficiency for many applications. Nevertheless, they still be interfaces that act by contact, hindering the movement of the operator or cause him to act through unnatural movements.

On the other side, if bilater interaction is not required, vision-based interfaces do not require physical contact with external devices, which means cables, connectors and unwanted objects outside of user's working area. This grant a more natural and intuitive interaction, which is reflected on task performance: in [10], the accuracy of object gripping tasks is improved by mean of a non-contacting vision-based method of robot teleoperation; in [11] a stereo vision system improved the performance for mobile robot teleoperation.

Moreover, if a vision-interface is integrated with virtual and augmented reality techniques, it translates in a greater level of immersion for the user. Such techniques are used to enhance the feedback information. In fact, the operator feels like being physically present in the remote environment, enhancing the immersion level; the notion of immersion is one of the most important reasons for using virtual and augmented reality [6].

Recently, in [12] is presented an augmented reality system for teleoperation based on Leap Motion (LM) controller. For its domain, the LM is considered an accurate sensor [13], however it is limited to a relatively small measuring distance if compared with other sensors. In this sense, it introduces spatial constraints that clash with the concept of high user immersion previously stated.

For this reasons, we present a novel robot augmented reality teleoperation system which exploits a common camera, which is provided by greater measuring distance compared with the LM. A ROS-based framework has been developed to provide hand tracking features. This, in combination with the ease of availability of a camera, lead the system to be strongly open-source oriented and highly replicable on all the ROS-based platform when compared with similar solutions. The proposed solution includes a rigorous calibration procedure and a set of gesture to specify user's actions.

Nella intro mettere reference al related work. Dalla intro spiegare il focus del paper e le novel contribution.

II. DEVELOPED SYSTEM

A. Hand-Gesture Recognition

Che rete uso, come ho impostato i gesti, lo scheletro con openpose citato, funzione per ricavare il gesto basata sull'assenza del finger, invariante dall'orientamento e dallo zoom. Immagini di esempio.

B. Workspace Calibration and Mapping

Qui spiego il problema del dover riferire i keypoints della mano ricavati nel primo workspace verde al workspace del robot per poterlo correttamente movimentare. I passi per questa procedura sono due: prima calibro il primo workspace

This work was not supported by any organization.

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verde rispetto a come la kinect lo inquadra, e questo sar il workspace di riferimento. Ottengo una trasformazione pixel to realeper sapere in metri dove posizionata la mano (i keypoints) nel workspace verde. Poi devo riferire questo workspace verde a quello in cui si muove il robot. Per farlo devo sapere il rapporto di mapping tra il w1 e il w2, cio a cosa corrisponde il punto 1 di w1 in w2 ecc. Poi devo fare la stessa cosa per capire qual il riferimento del robot rispetto a w2. Per farlo devo muovere sperimentalmente il robot in diverse posizioni del master e ricavare a cosa corrispondono nel master rispetto al robot per ottenere questo mapping. Immagini che rappresentano questa procedura. Procedura di calibrazione automatica?

III. EXPERIMENTS

Due esperimenti: uno sulla ripetibilit del posizionamento del robot rispetto alla teleoperazione e uno sul posizionamento corretto del robot su un oggetto stampato in 3D per l'esperimento. Specifiche del set-up utilizzato: rappresentazioni dei master di calibrazione usati, specifiche delle loro dimensioni, robot usato, pinza customizzata con laserino, oggetto 3D stampato.

A. First experiment

Spiegazione della procedura. Descrizione della pinza laser usata per il posizionamento accurato. Come prendo i dati? Lascio gi un segno sul master (a mano?), prendo una foto? Risultati ottenuti. Commento.

B. Second experiment

Descrizione della piastra 3D stampata per l'esperimento e obiettivi. Risultati ottenuti. Commento.

IV. USING THE TEMPLATE

A. Figures and Tables

Positioning Figures and Tables: Place figures and tables at the top and bottom of columns. Avoid placing them in the middle of columns. Large figures and tables may span across both columns. Figure captions should be below the figures; table heads should appear above the tables. Insert figures and tables after they are cited in the text. Use the abbreviation Fig. 1, even at the beginning of a sentence.

TABLE I

AN EXAMPLE OF A TABLE

One	Two
Three	Four

We suggest that you use a text box to insert a graphic (which is ideally a 300 dpi TIFF or EPS file, with all fonts embedded) because, in an document, this method is somewhat more stable than directly inserting a picture.

Fig. 1. Inductance of oscillation winding on amorphous magnetic core versus DC bias magnetic field

Figure Labels: Use 8 point Times New Roman for Figure labels. Use words rather than symbols or abbreviations when writing Figure axis labels to avoid confusing the reader. As an example, write the quantity Magnetization, or Magnetization, M, not just M. If including units in the label, present them within parentheses. Do not label axes only with units. In the example, write Magnetization (A/m) or Magnetization A[m(1)], not just A/m. Do not label axes with a ratio of quantities and units. For example, write Temperature (K), not Temperature/K.

V. CONCLUSIONS

Conclusioni sul progetto/esperimenti ottenuti. Problematiche incontrate e come sono state risolte. Future developments.

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