Friendly Interface for Objects Selection in a Robotized Kitchen

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Abstract

This paper presents an interface for the interaction between a human and an adapted kitchen where different elements, including a robot, have to be controlled. After the global structure of the interface is described, a more detailed explanation is presented on the way the interface offers the user an easy and friendly way to select the desired objects and to provide their position to the robot for their manipulation.

Keywords: Technology and disability, interface and computer vision

1 INTRODUCTION

Independent living constitutes an increasing need in our society today. Age and a great number of different disabilities prevent many people from living autonomously. For these reasons, for a long time, some research and development has been done to progress towards the possibility to provide disabled with devices or systems that allow increasing their autonomy. The kitchen is a part of the house where different technological aids can become essential for personal autonomy. There are studies about the main user's needs and ergonomic requirements in such environments [2, 6] useful in the design of such aids. Among many other projects on Robotics assistive technology, the CAPDI project [3] is centered uniquely to the assistance in the kitchen, focusing towards the main needs there. The project combines the use of a robotic arm, when needed, with other adapted elements to enable the user to gain some independence. Being the user's acceptance [1] one of the critical aspects to be considered, a friendly interface that facilitates the selection and location of the different objects in this environment has been developed. This paper presents two different methods for selecting objects which have to be manipulated by a robot arm in a kitchen adapted to disabled. Both methods are based on normal human behaviors such as figure 1 depicts. The first method consists on sequentially presenting the different objects of the scene and the user interacts with the system by a simple "yes" or "not" mechanism. The second method consists on the direct recognition of the object indicated by the user.

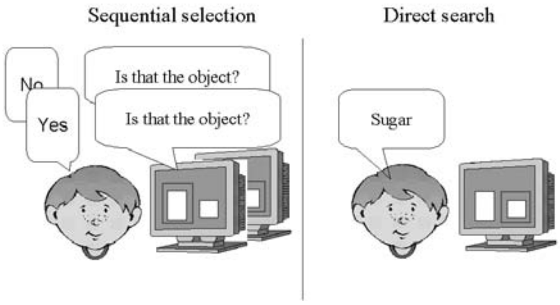

Figure 1: As a simple schema, the central idea of the two interfaces proposed for object selection.

1.1 *The CAPDI kitchen*

The CAPDI kitchen (Adapted Kitchen for the Disabled) has been conceived as a modular system that can be adapted to users with many different degrees of disability. The kitchen can be progressively adapted to the evolving user's needs, due to age or to a degenerative disability.

One of the most important problems in a kitchen is the accessibility to the different items. For more severely disabled people a robot arm is also included in the adapted kitchen. The objective of adding this new and more complex element is to enable such users to manipulate objects and to perform simple tasks that allow them to gain some autonomy. Figure 2 shows the laboratory kitchen prototype with a robot and a carrousel cupboard, and shows too the kitchen interface for local area visualization and control of its elements.

Figure 2: The left image shows a first prototype of the robotized kitchen in the lab environment. The right image is a view of the kitchen interface.

To facilitate the user interaction with the robot, a vision system can be used to locate the desired objects and to guide the robot towards the target. A panoramic camera, (or more than one) can visualize the selected area (areas) where the robot has to move to pick up an object. A local camera, over the robot, can locate more precisely the object when the gripper is close and the arm occludes the panoramic view. In what follows, the structure of the user's interface as well as the method to efficiently select the objects to be manipulated by the robot arm is presented.

2 VISUAL INTERFACE

The need for elder or disabled people to interact and control all the different kitchen elements has forced to design a friendly interface. The vision system locates the objects in the scene by interacting with the user and permits to choose the one he desires. This objective can be achieved following different strategies, as depicted in figures 3 and 5. In the first option, named "sequential selection", the interface marks sequentially the items that could be of interest to the user. The user interacts with the system by a simple "yes" or "not" mechanism. In the second option, named "direct search", the user indicates which is the item of interest, so that the system search this item in some pre-specified location.

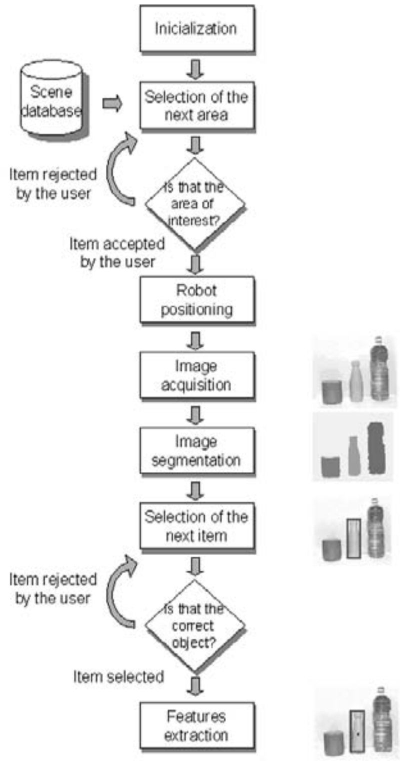

Figure 3: A scheme of the bottom-up approach for object selection.

2.1 *Bottom-up approach*

Figure 3 shows the block diagram of the method which is based on a sequential selection of the area of interest and of the segmented imaged objects. The user selects one area of interest, the one where he supposes the object to be manipulated is placed. Once the area is selected, the robot arm is positioned in a pre-defined 3D position, from where the local camera attached to the arm can acquire the local image. The process of segmentation is the core of the bottom-up interface and consists on the partition of the imaged scene into meaningful regions. In the following we present a new algorithm which achieves reliable results in reasonable time, as required by the application.

2.1.1 *Image segmentation*

Region-based techniques often fail to yield the desired structure due to the difficulty of choosing a reasonable starting "seed" point, and appropriate growing or stopping rules. Similarly, edge-based techniques often fail due to the similarity of objects within the scene or indistinct boundaries between image objects. Combining both edges and regions segmentation approaches lead to better results [5, 7]. The first step of the segmentation process is to extract the most significant contours of the image [4]. Then, the growing centers (the "seeds") are placed at both sides of the contour and along it as illustrated in figure 4. All the seeds starts at the same time a concurrent growing algorithm. Finally, the initial regions should be merged to eliminate small regions.

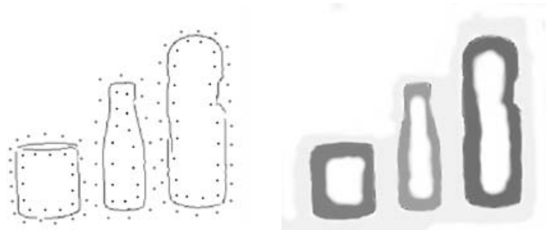

Figure 4: Scheme showing different phases of the proposed segmentation algorithm.

2.1.2 *Selection of the items*

The various regions are run over sequentially, with a new item offered to the user at each step. The item is offered through a visual effect highlighting the region containing the item in the original image. The user may reject the items offered until the one he/she wishes is reached. At this point the examination of the different items in the image stops.

2.1.3 *Feature extraction*

Finally we focus only on the item chosen and all the information the arm requires in order to effect the movement is extracted. The essential data are: the spatial location of the item and its measurements. It is also very important to try to recognize the item in such a way that a strategy for determining the best way to grasp and manipulate the item can be worked out.

2.2 *Top-down approach*

Figure 5 shows the block diagram of the proposed method. The strategy here is to directly search a given object by exploiting the knowledge about the scene. The information concerning the specific characteristics of objects is contained in the object model databases. On the other hand, the list of objects that are expected to be in the kitchen and their relationships, and expected positions are contained in the scene model database.

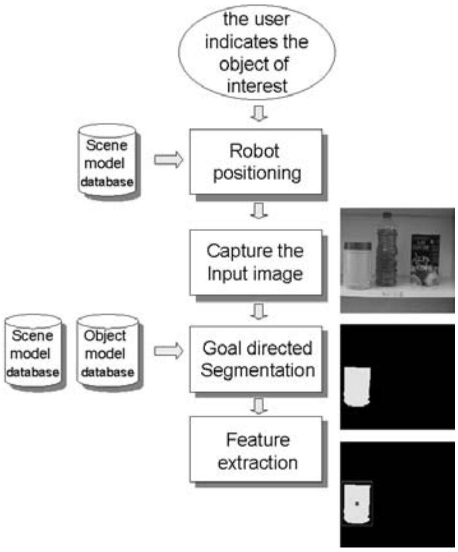

Figure 5: A scheme of the top-down interface for object selection.

2.2.1 *Scene and object modeling: learning the environment*

The scene model is constructed with a graphic interface by relating objects that have been previously characterized in the object modeling task. In the scene model the objects can be connected by three kinds of relationships: spatial, KIND-OF and COMPOSED-BY.

Object modeling starts with an interactive process where a teacher selects meaningful examples of objects in training images by clicking on blobs of pixels. This process enables to compute several color and texture features for every blob. Afterwards, the system selects the features that best characterize each object class, i.e. those features which separate the clusters in the feature space representing the object samples in some optimal way.

The process of data model acquisition can be performed a priori, setting up an initial scenario. But, realistically in a normal kitchen new objects can appear and some others disappear. When a new object appears in the kitchen for the first time, and the user wants to select it, it is necessary to use the bottom-up approach. Then, the user has the possibility to indicate to the system that this object (a segmented region of the image) is new, and has a given name. Afterwards the system updates its database acquiring the object's location and extracting their most significant features. This behavior facilitates the knowledge engineering task because knowledge is acquired incrementally.

2.2.2 *Segmentation based on previous learning*

Following the "divide and conquer" paradigm, a decision tree separates the samples of the training images in a recursive way. The decision trees considered in our approach are binary trees with multivariate decision functions, where each node is a binary test represented by a linear function. Each node of the tree attempts to separate, in a set of known instances (the training set), target (mapped as +) from non-target instances (mapped as −). The resulting two subsets of samples are again subdivided into two parts by using two new calculated linear functions. This process is extended in a binary tree structure until an appropriate misclassification ratio is achieved. The result is a tree of hyperplane nodes that recursively try to divide the feature space into target and non-target samples.

The segmentation algorithm consists of dropping each pixel of the image down the tree, so that the pixels will be classified as + or −, representing the + a segmented pixel for that object class. Due to problems related to the fact of dealing with real images it is possible that some segmentation errors appear. Then, to improve the initial results, a final region growing process tries to fit these regions successfully.

3 CONCLUSIONS AND FUTURE TRENDS

In the paper an interface specially designed for disabled users in a robotized kitchen has been described. In this sense, two main principles have guided the design of the interface: easy-to-use and open-interface. The goal has been to provide a friendly way to access to different objects as well as an interface which can be adapted to different kind of disabled people. Although two different methods have been presented, they have been conceived as complementary. Furthermore, bottom-up and top-down approaches collaborate in the knowledge acquisition process that is necessary for top-down operation. This interface is being now evaluated by users with different degrees of disabilities to extract from the user's trials the functional and operatives performances and limitations. By now, we are working on preparing the interface to accept voice input orders which will facilitate object selection tasks and improve the communication between the user and the whole system.

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