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Sujet de thèses 2014

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Titre de la thèse : **Reconnaissance tactile d'un objet dans une main robotique**

Résumé du sujet

Avec l'augmentation du niveau de vie et le vieillissement de la population les robots sont appelés à remplacer l'homme dans de nombreux domaines. Diverses mains robotiques ont été développées avec différents niveaux d'anthropomorphisme pour reproduire les fonctions de la main humaine. Leurs capacités de préhension sont principalement basées sur des informations provenant d'un système de vision qui la plupart du temps ne suffit pas. Lorsque l'objet est occulté éventuellement par la main, il n'y a plus d'information et le système risque de ne plus fonctionner correctement. Comme chez l'homme, c'est dans ces situations que l'information tactile devient cruciale pour effectuer une reconnaissance de l'objet. Plusieurs articles ont été publiés dans lesquels les informations provenant de capteurs tactiles sont utilisées dans cet objectif, spécialement celles provenant de matrices tactiles (TAS). Certains de ces travaux montrent que par la conversion de ces informations en images, les techniques de traitement d'images peuvent être mises en œuvre pour réaliser la reconnaissance de l'objet et de sa forme. Des informations (images) provenant simultanément de plusieurs TAS combinées avec le modèle cinématique du système robotique permettraient de fournir plus d'informations sur les formes géométriques de l'objet et, par conséquent, la reconnaissance et la manipulation de l'objet seraient facilitées. Ceci reste un sujet inexploré. Au cours de cette thèse, la main robotique du projet européen HANDLE sera équipée de plusieurs TAS et utilisée pour effectuer non seulement la reconnaissance d'objets, mais aussi l'extraction et l'estimation d'une cartographie 3D qui sera utilisée plus tard pour manipuler l'objet. Des techniques incomplètes de traitement d'images seront utilisées. Par ailleurs, d'autres paramètres représentant le caractère mou ou glissant de l'objet, par exemple, seront également estimés par l'utilisation de données dynamiques afin de réaliser plus efficacement la planification de la saisie. La vision ne doit pas être mise au rebut pour autant. Un algorithme sera développé pour effectuer une reconnaissance d'objet passant de la vision au toucher. Le processus de cartographie 3D mentionné précédemment sera utilisé pour passer du toucher à la vision. Des simulations Gazebo du système seront réalisées pour générer des données haptiques et des images de chaque objet vu. A la fin des travaux, le système devrait être capable d'émuler la capacité humaine à reconnaître un objet en en combinant vision et toucher.

Sujet développé

With the increase of living standards of society and the aging of the population in-door robots are expected to replace humans in many areas. Obviously, the end-effector plays an important role in the performance of the robot. Various robotic hands have been developed with different levels of anthropomorphism to reproduce the human hand functionality. The capability of executing multiple grasping patterns and fine movements in hand like the human hand allows the robot to perform intelligent in-hand manipulation of an object provided the handled object and its dedicated tasks are recognized. The visual information on the object, through a Kinect camera as an example, is not enough. Indeed, during the in-hand manipulation, the object might be occluded by the hand itself. Thus, it seems imperative to give the robot the capability of using more that just a vision system so that it reacts to changes in the environment in an efficient way. Data obtained from tactile sensors can provide this capability; indeed, this data can be used for object detection, classification, recognition, and manipulation. There are already some works on object recognition and shape recognition with tactile sensors, and manipulation algorithms that use tactile information have also been proposed as well as 3D shape reconstruction methods. Nevertheless, an advanced autonomous robotic manipulation system that combines information coming from multiple sensor arrays installed over a robotic hand for object recognition hasn't been developed to the best of our knowledge.

Among the efforts that have been made in order to achieve object recognition through information obtained from tactile sensors, several results show it is feasible. Some of the work done used tactile arrays information and converted it into images in order to treat it with image processing techniques. Pezzementi et al [1] used tactile images to implement a bag-of-features technique using novel image descriptors algorithms based on Fourier transform with excellent performance, being able to recognize an object with an average accuracy of 80 percent on several trials. Khasnobish et al. [2] also used tactile image for object-shape recognition and 3D reconstruction with an implementation of a hybrid recognition scheme that uses not only the considered features obtained through images, but also gradient-related information of these images. Some more object or shape recognition work has been done, like that of Khasnobish A. et al [3] using feed-forward Neural Networks for object clustering and classification. Other sorts of tactile data have also been used in object shape recgonition, such as the geometrics of the object [4]-[6]. Regarding the active object recognition, little work has been done. Most of the work done has been focused on the use of static data related mostly to one single array to recognize either objects or shapes.

Certainly, tactile data would definitely provide with the information needed to recognize an object when this is not in the vision range of the robot. But one more challenge arise from this: how to acquire this data? The exploration of the object has then an importance that needs to be taken into account. Furthermore, most of the works previously mentioned focuses on the treatment of the data, but very little focuses on the reconstruction of an object model by the use of tactile data, not to mention that treating data coming from multiple sensors simultaneously remains an unexplored subject.

After identifying these limitations in previous research, the following PhD thesis work plan is proposed:

- *Recognition and reconstruction of a 3D model of an object through data coming simultaneously from different sensors installed in a morphologic hand.*

  By using data coming from different sensors simultaneously, image-processing techniques like bag-of-features or eigen-faces, can be used to recognize the object. Since the patches of sensors will be separated onto the hand, the result is not a complete image, but several seperated ones. In order to treat them, algorithms to treat imcomplete images, like the ones presented in [8] to [10] can be used. In addition, the kinematic model of the robotic hand will be used to know relative position of each sensor in space, which would help to infer a 3D model of the object.

- *Study the way humans explore unknown objects in order to create an exploration algorithm to be implemented in the morphologic hand to collect the data needed.*
  By using the data that the ISIR got from the HANDLE project [11], several different experiences can be designed to study how human do haptic exploration. With the data obtained from these experiences, feasible techniques of exploration in a robotic hand will be designed to be implemented and get the data correctly.
- *Using dynamic data coming from the sensors and use it not only in recognition but also for other parameters estimation, as softness, that can be used for dexterous manipulation algorithms.*
  Once the recognition is achieved, the next step will be recognizing pattern in images that would tell whether the object is deformable or not [7]. Slippery patterns will also be detected [12] by treating the dynamic data through signal processsing techniques. These parameters and the kinematic model of the hand will be used to implement an active exploration strategy of the object (such as shown in [11]) in order to recover its shape. This technique will combine spatially and temporally the results of the static reconstruction obtained in the first step of this work.
- *Using visual information to develop the 3D model and increase the list of recognizable objects as well as to transform the visual data into tactile information.*
  As humans usually use both tactile and vision information to recognize, caracterize and explore the objects, integration of a vision input with tactile data will also be used as it happens in humans [13]. This vision and tactile combination will not only be used to reconstruct and recognize unknown objects, but also to recognize objects which are already known from vision. The geometrical features of these objects are to be taken into account in this case.

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