Towards an Electric-Sense-Based Bioinspired Embodied Robotic Perception System: The Modelling Aspect

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Technical Report of École des Mines de Nantes, Institut de Recherche en Communication et Cybernétique de Nantes and SUBATECH.

Date de création : 5 avril 2011
Dernière modification : 6 juin 2012

In the context of the new paradigm of embodied intelligence invoked by both the roboticians and the cognitive scientists, a sensor bio-inspired from the electric fish was built. A certain geometry was pointed out for an accurate analytical prediction of the electrical measurements on the body in the presence of exterior objects. Such perception model can establish potentially a direct relation between the location of the object and the body positions measurements as well as the shape of the object and the body direction. In addition to a potential novel tomography technique and a new potential electrolocation system it offers new insights in understanding the role of the body in perceiving the world..

Keywords

Electrolocation, perception active, capteur bio-inspiré, réduction de modèle, électrocinétique, électrostatique

1 Introduction

Since the discovery of electrolocation by Lissmann [3] many scientists tried to understand more deeply what were the electric cues from which the fish deduce some crucial parameters in order to hunt, to communicate [1]...Recently scientists began to use the technology to understand some biological behaviours. In 2008 the first electrolocation system [4] was built. The author succeeded in locating an object using some electric measurements on a 2D robot. Although the results were satisfying the author excluded the body using punctual electrodes. In addition the algorithm used was time consuming. These constraints cannot obviously lead to an embarked dynamic electrolocation system and of course cannot give a relation between the body and the perception. Actually the new paradigm of *embodied intelligence* defines a new direction for both roboticians and biologists. More and more scentists agree to consider that perception is intimately associated to the body and one may argue that all the robots or the cognitive understandings are not coherent when they are separated from the body. From a physical point of view this is obvious. It is the contribution of the European project ANGELS to not separate the body from the perception by building a fish like robot which can perceive its surroundings by an artificial electric sense. In this article we focus on the modelling of the electric perception by a real volumic body. We establish from a physisict's point of view the relation between the perception and the body using a simple analytical approach [2]. We also give using the model and a non isotropic object the relation between the shape of the object and the direction of the body. We illustrate finally that when coupled to a defined action the theoretical fish-like robot can locate an object and distinguish its shape from an other.

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2 The body as an "electric screen"

The fish uses its own body and its field to locate objects in the waters. As an inspiration we take this fact to build a sensing model for our fish like robot. The PSM model [2] permits to predict the perturbation of a small object on a sensor of slender geometry. The model can be expressed as following :

$$\mathcal{I} = (\mathcal{C}_0 + \delta\mathcal{C})\,\mathcal{U} \tag{1}$$

Where $\mathcal{I}$ stands for the measured currents on several spherical electrodes, $\mathcal{C}_0$ is the conductance of the medium with no object, $\delta\mathcal{C}$ is the perturbation of the conductance induced by the presence of the object and $\mathcal{U}$ is the voltages imposed on the electrodes in order to create like the fish an electric field. The model as simply as stated consists in several spherical electrodes distributed on a line and separated by a distance such that it prevents from any mutual perturbation. The virtues of the model are mainly the following ones : firstly the ability of reproducing with good accuracy the measurements performed by a real sensor of volumic extent by calibrating once for all offline the dimensions of the electrodes with the reference measurements given by a simulator or the experiment. Secondly, the model integrates easily the perturbation of an object provided we know its polarizability, which is given in the litterature for several objects. Given an object we are able to predict according to the measurements its position along the body of the sensor. A small sphere placed to a certain distance from the sensor at a x_0 position along the body of the sensor will lead to a maximum of perturbation in the closest electrode to the x_0 position. Then a maximum of perturbation recorded by an electrode of the moving sensor will give us the x_0 position of the object which will correspond perfectly to the position along the body of the so called electrode.

3 Object distinction and body direction

Another important fact is the role of the body direction in the distinction of objects. To understand how this ability is well achieved by our fish like robot we can illustrate this point with the use of non isotropic object like a spheroid. More explicity in this case a relation must be found between the direction of the sensor body and the ability of distinguishing the spheroid from the sphere. The answer is the relation between the direction of the field and the body. As the sensor acts as a simple dipole like the fish it creates a field with a direction that is directly related to the direction of the body. Taking a simple sensor consisting of two electrodes of opposite magnitude will make more simple the explanation. In fact for this kind of sensor, the field at the mid distance from the electrodes is parallel to the body as for any dipole. Then a spheroid that is placed at the mid distance from the two electrodes will be scanned by a field that is parallel to the body. We deduce simply that if the bigger axis is found to be parallel to the field, i.e. parallel to the body axis, then it will lead to a bigger perturbation than in the case where it is the smaller axis that is found to be parallel to the field, i.e. parallel to the body of the sensor. This simple example illustrates the principle of the object recognition. In principle our fish like robot is able to decipher an object from another by a simple rotation of its body.

4 Conclusion

Electrolocation is the perfect topic to express the relation between embodiement and perception. The first results obtained in the project ANGELS are encouraging. Locating a small object can be achieved with a simple analytical model inline by the information of maximum perturbation on a point of the body corresponding to the center of an equivalent charged spherical electrode. We believe also that with such a perception model and the existence of a simple relation between the direction of the body and the scanning field, it is likely that we will be able to perform inline as well object recognition and decipher for example one object from another by a simple body rotation and a comparison of electric perturbation. The ANGELS project is funded by the European Commission, Information Society and Media, Future and Emerging Technologies (FET) contract number : 231845.

Références

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