Is it Necessary to Explicitly Solve the Redundancy Problem when Learning the Inverse Kinematics of a Robotic Arm?

Rasmus Baath
rasmus.baath@lucs.lu.se

Christian Balkenius
christian.balkenius@lucs.lu.se

Lund University Cognitive Science

The Redundancy Problem

One problem faced by both humans and robots is that arms often have redundant degrees of freedom. Redundancy is useful as it increases the flexibility of the arm, but it also poses a problem in that there are more than one correct way to position the hand at an endpoint. Earlier attempts to learn inverse kinematics have either used a non-redundant arm or added an extra mechanism that explicitly deals with the problem of redundancy (see e.g. Butz et al., 2007).

Here it is investigated whether learning the inverse kinematics of a redundant arm can be done using a standard learning algorithm without explicitly solving the problem of redundancy.

Method

A 2D two-joint arm was simulated and a feed forward ANN was trained to associate a desired endpoint, \( G = (x_g, y_g) \), and the current joint angle configuration, \( \theta = (\theta_1, \theta_2) \), with the joint angle displacement that positions the arm endpoint at \( G \). Training examples were collected by allowing the arm to motor babble (Demiris and Dearden, 2005) by moving it around in small steps of normally distributed random lengths.

Initially SD was set to 10° but was successively raised to 12° and 15°. To evaluate the performance of the trained ANN it was measured how long the path of the arm was when reaching for a randomly placed \( G \). To investigate how the number of training examples, \( n \), influenced the performance, ANNs where trained using \( n = (2^6, 2^7, \ldots, 2^{14}) \).

Result

The aim of the current study was to investigate if it is possible to learn the inverse kinematics of a redundant arm without explicitly solving the redundancy problem. Given this aim the model performs surprisingly well. When the number of training examples are large the arm manages to reach the desired endpoint 96% of the time. A limit of the model is that presented with a goal position only one solution is given.

Conclusion

Is it necessary to explicitly solve the redundancy problem when learning the inverse kinematics of a robotic arm? Given the result of the experiment presented the answer would be "no". Thus when constructing a learning robot one might not need a redundancy solving component and the search for such in the human motor system, might not be necessary.

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References
