**Robust Control of Robotic Manipulators using RBF Neural Networks**

1. **Introduction**

The dynamic equation of an n-link robotic manipulator is given by:

where,

* is the inertia matrix of dimensions
* is the matrix containing Coriolis and Centrifugal terms of same dimensions as inertia matrix.
* is the gravity matrix of dimensions
* is the joint torques vector.

In many practical applications, we are unaware of , and . For this we can propose 3 different RBF neural networks which will calculate the values for , and **.** If **,** and are the ideal values of the respective matrices, i.e, the actual values of these matrices, and **,** and are the outputs of ideal RBF networks, we can write the following equations:

Here, are the modelling errors of , and respectively.

On substituting the above equations in the dynamic model, we get

where,

Obviously, the RBF networks in practice are not ideal, hence, we can only estimate the values of , and.

These estimates are written as:

Here, , and are estimates of , and

1. **Controller Design**

First, let us define the error terms:

Defining,

we have,

Now, we propose the following controller:

Here, is the model-estimated control law given by:

And is the robust term designed as:

For finding the adaptive law for updating the weights of networks, we have to perform the Lyapunov Stability Analysis of the Control Law proposed which leads us to the following adaptive law:

Here, , and are the learning rates for the respective RBF networks.