On the Relation between Neuro Fuzzy and CMAC Controller

Dr N.H.Siddique, School of Computing and Intelligent Systems, University of Ulster

Dr Richard Mitchell, Cybernetics, School of Systems Engineering, University of Reading

This paper proposes a learning mechanism where the rule base of the neuro-fuzzy controller is replaced by Albus's CMAC controller. The controller is applied to a flexible link manipulator and its performance verified.

Flexible Manipulator

Arm dimensions:
$190x19x3.2mm^3$
Mass density:
$2710\ kg/m^3$
Young Modulus:
$71x109\ N/m^2$

FLC for Flexible Manipulators

Most of FLC reported for flexible manipulators are Mamdani-type

FLC with 2 inputs requires $n \times m$ rules, n and m are the number of primary fuzzy sets.

Number of rules grows exponentially as the number of inputs increases.

Performance of Mamdani-type FLC depends on the amount of time required for rule-base processing and the defuzzification methods used.

Elimination of Rule Base and Defuzz..

Problem of defuzzification methods eliminated by the use of Sugeno-type fuzzy systems

Roger Jang first introduced an adaptive-network-based fuzzy inference system; serves as a basis for constructing a set of fuzzy if-then rules.

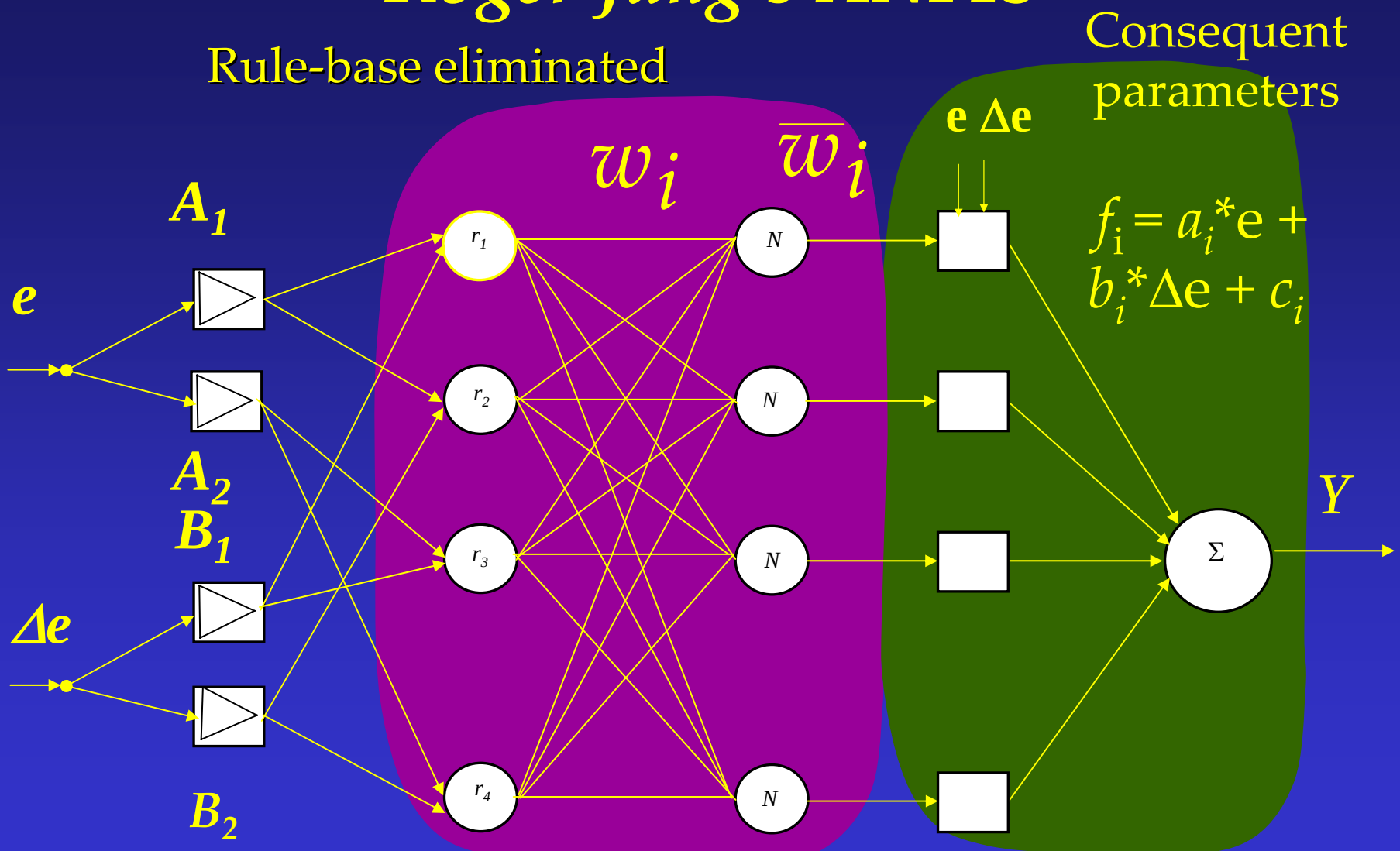
Sugeno type FLC

consequent part represented by a parametric polynomial function

No need for defuzzification of fuzzy sets in consequent

Roger Jang's ANFIS

Rule-base eliminated



Parameter Estimation

This further imposes a set of premises and consequence parameters to be learnt/estimated

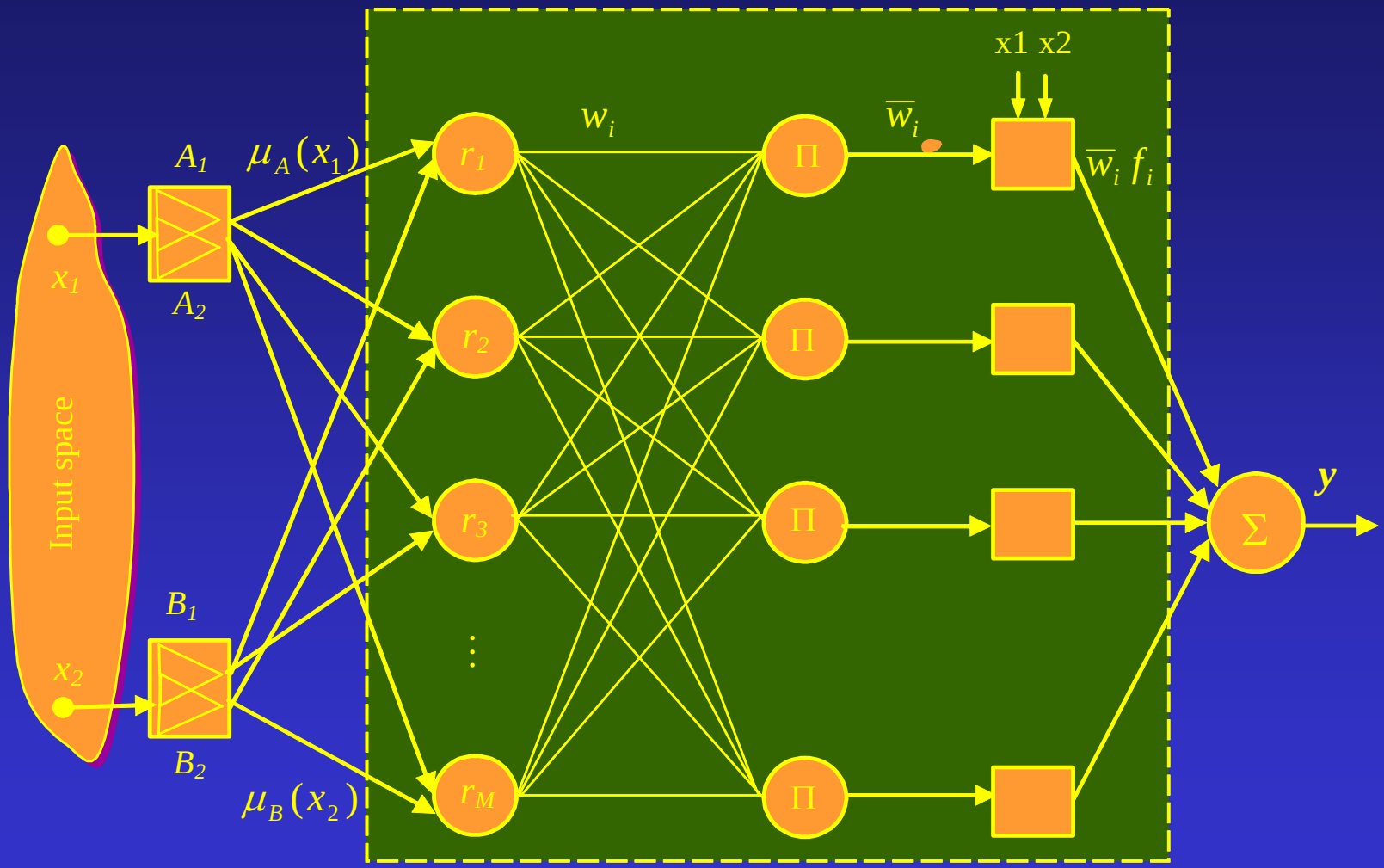
Consequent paras found by LSE in forward pass

Premises parameters are updated by gradient descent in the backward pass.

Application of algorithms depends on trade-off: computational complexity v resulting performance.

In the case of a flexible-link manipulator - online calculation involves inversion of large matrices, which degrades the ultimate performance. So ..

Neuro Fuzzy Controller



Albus' CMAC

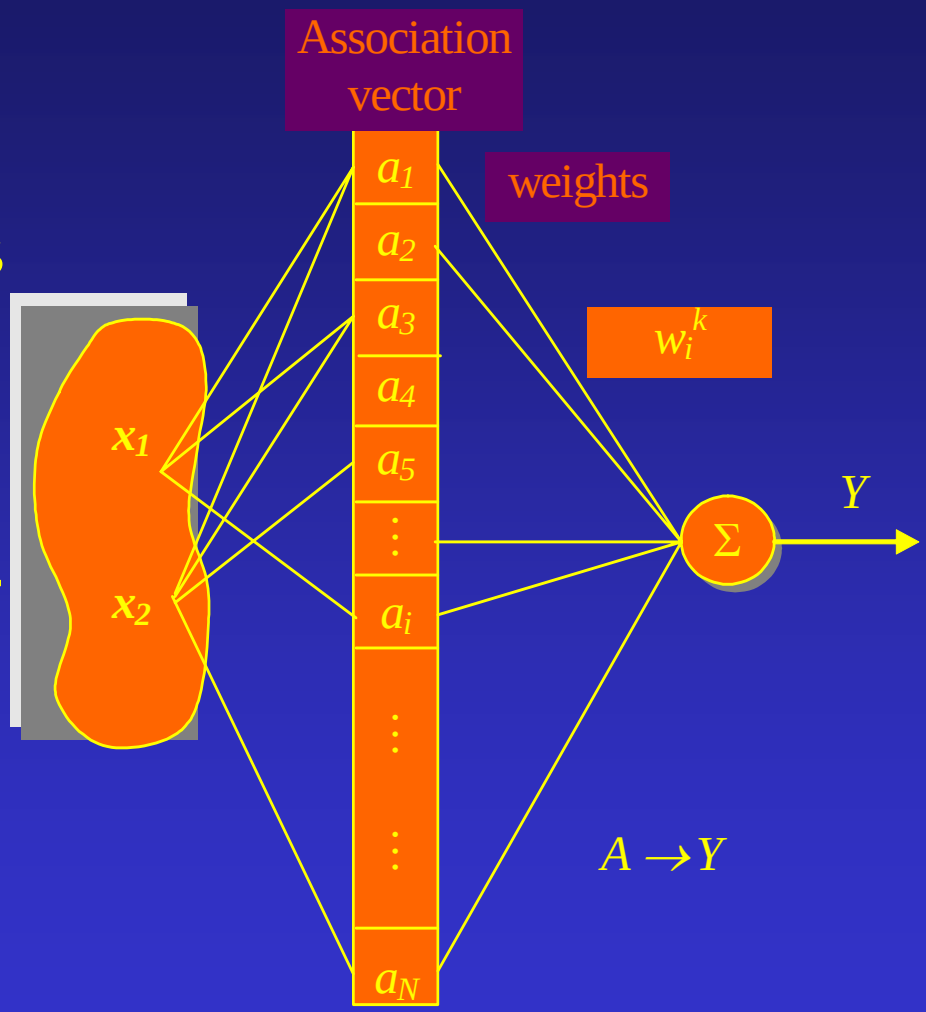
CMAC can approximate a nonlinear function

Fixed mapping transforms each μ into an N-dimensional binary association vector

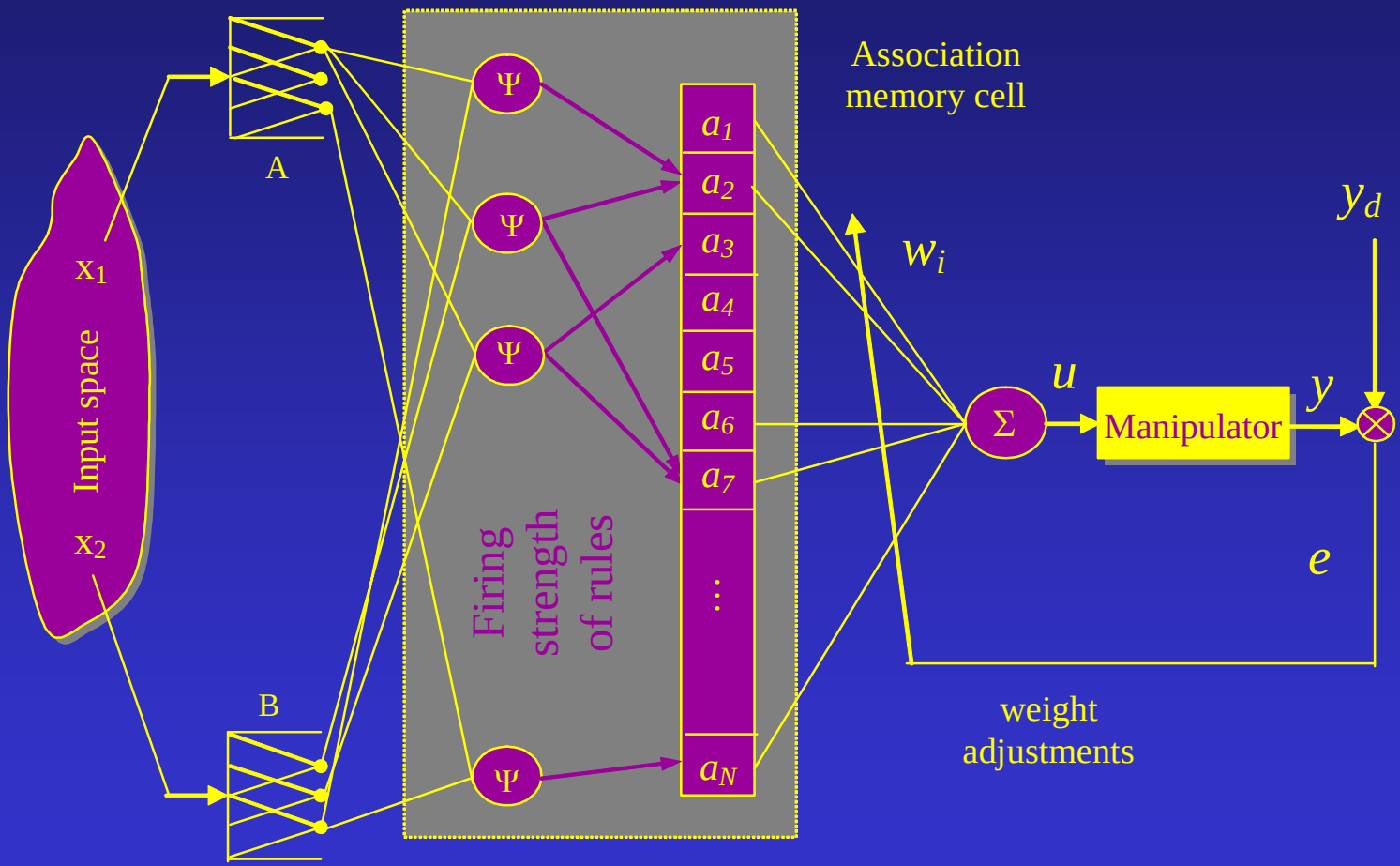
Mapping is a procedure of summing the weights of the association cells

Output is a weighted sum

Weights are to be learnt

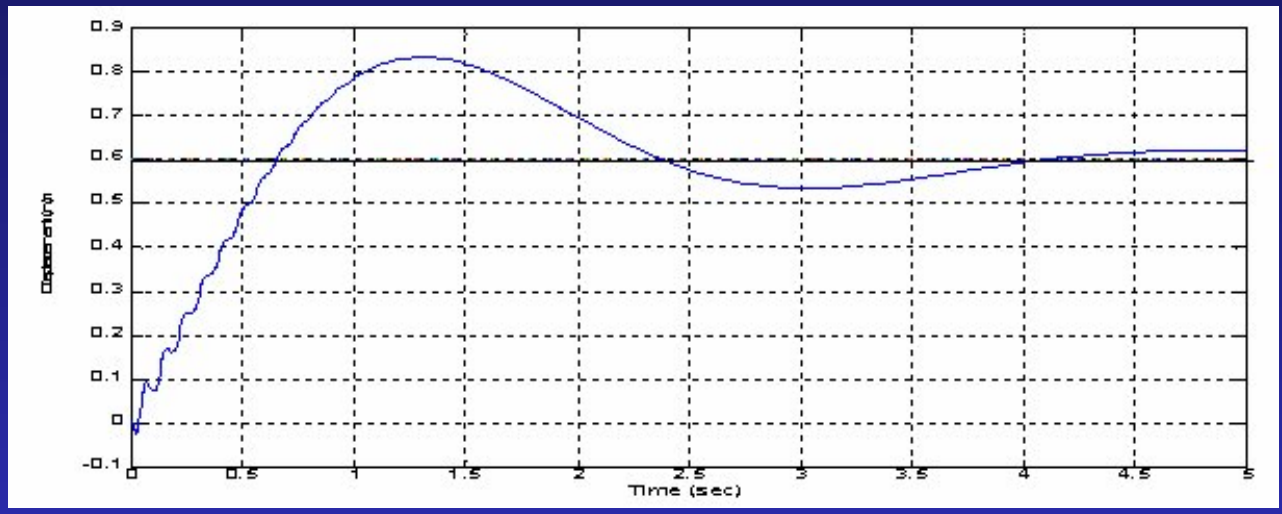


Fuzzy CMAC Controller

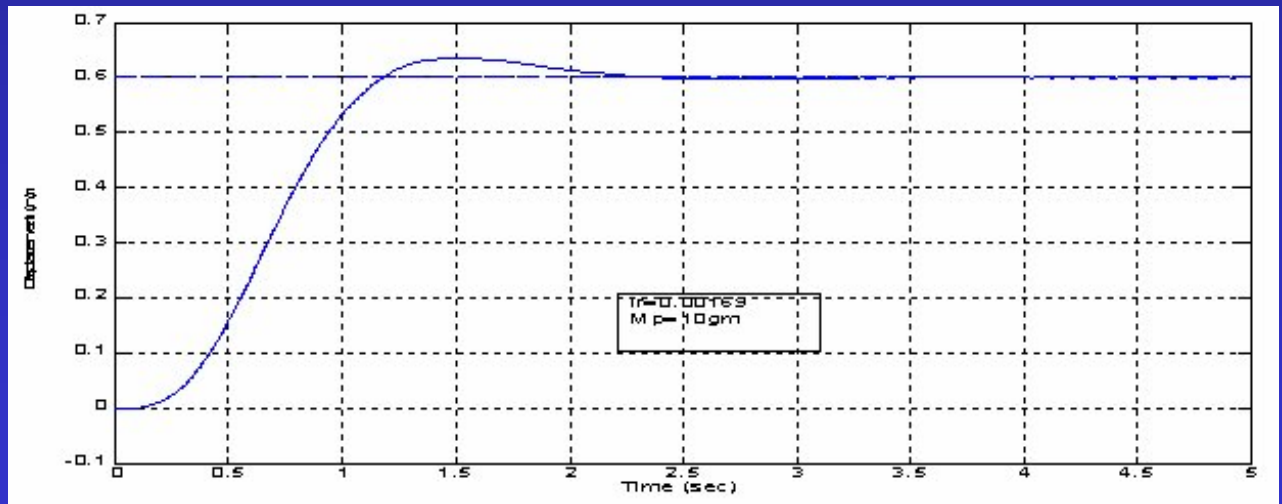


Manipulator Responses (same scales)

N-Fuzzy

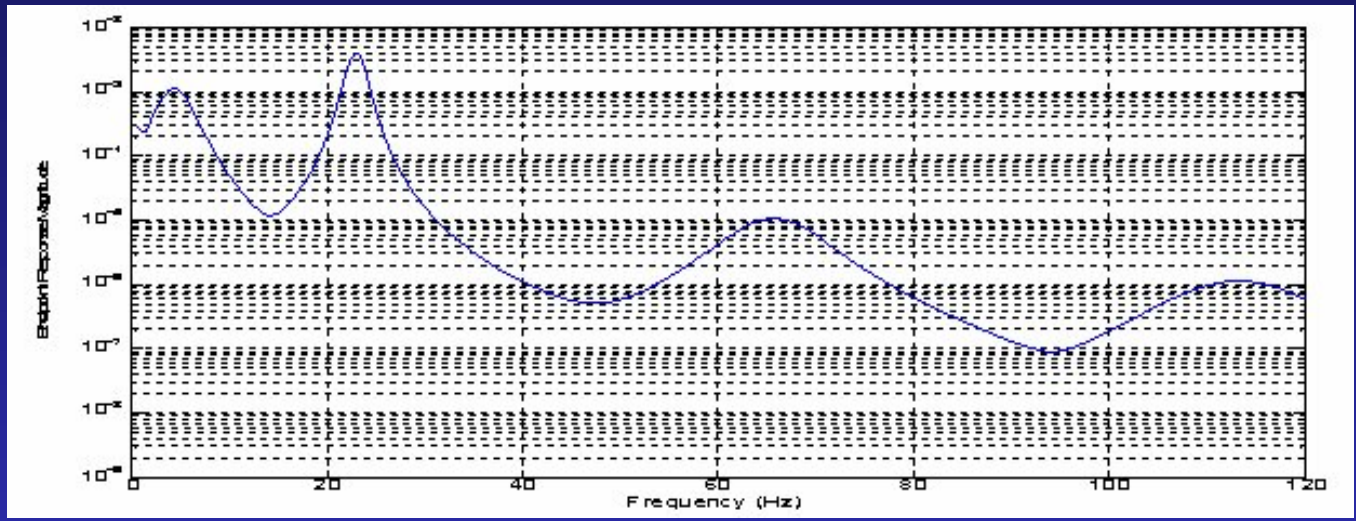


FCMAC

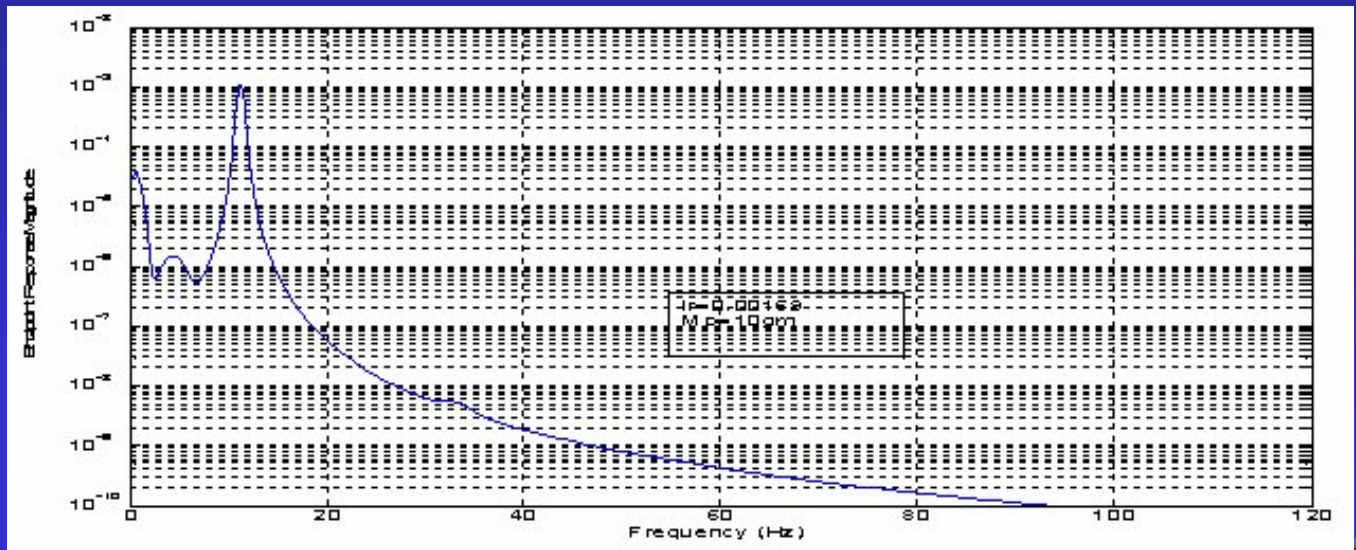


End Point Vibration (Mag vs Freq)

N-Fuzzy



FCMAC



Conclusion

FCMAC faster, but poorer end-point vibration

Main advantage of the FCMAC scheme over the neuro-fuzzy controller is the reduced number of parameters that is to be learnt.

Neuro-fuzzy controller has 27 parameters to be estimated from I/O data

FCMAC has only 9 weights to learn

This has further reduced the computation time during operation.