FUZZY SYSTEM PROJECT REPORT

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Table Look Up Algorithm

Fuzzy Systems Course

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Designing Fuzzy System using Table Look Up Scheme Report

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Time Series Prediction.

Time series prediction is an important practical problem. Applications of time series prediction can be found in the areas of economic and business planning, inventory and production control. Here we use the fuzzy system designed by the table look-up scheme to predict the Mackey-Glass chaotic time series that is generated by the following delay differential equation.

$$\frac{dx(t)}{dt} = \frac{0.2x(t-\tau)}{1+x^{10}(t-\tau)} - 0.1x(t)$$

To write MATLAB code easier, we write this equation for $\tau = 30$ as follows:

$$x(t+1) = \frac{0.2x(t-30)}{1+x^{10}(t-30)} + 0.9x(t)$$

The implementation of this equation is given in " 2nd Part: Data\ Sampling" part of the code. Sampling Data and Training Data are generated by this equation. Here is the code:

```
SAMPLES = rand(1,32);
for v=33:1033
    SAMPLES(v) = 0.2*SAMPLES(v-31)/
(1+(SAMPLES(v-31)^10))+0.9*SAMPLES(v-1);
end
```

```
SAMPLES = SAMPLES(34:end);
```

Rule Base.

Rule Base is the most difficult and important part of the program. In this method, a fuzzy rule base is created based on the available data from the system. Then, based on that rule base, a fuzzy system is designed that has the ability to model the system.

To form a rule base, we must first identify the member functions of data pairs. This code gives us the number and amount of the membership function using the slope and the initial values and the type of membership function.

```
Step = (UpBnd-LowBnd)/(Num-1);
        for i=1:Num
            Center = LowBnd+(i-1)*Step;
            Y(i) = trimf(x,[Center-Step,Center,
Center+Step]);
        end
```

This code is a created function named “ MFDetector.m ”.

After detecting membership function number and value, we use following code as a function to find the rules. The function is named as “ RuleFinder.m ”.

```
e1 = numel(MFNum);
e2 = size(Pair,1);
MVal = zeros(1,e1);
MFun = zeros(1,e1);
Rule = zeros((size(Pair)));
RuleMemValue = zeros((size(Pair)));
```

```
    for i=1:e2
        for j=1:e1
            [MVal(j) MFun(j)] =
MFDetector(Pair(i,j),MFNum(j),LowBnd(j),UpBnd(j)
,MemFunTyp(j));
        end

        Rule(i,:)=MFun;
        RuleMemValue(i,:)=MVal;
    end
```

The brief explanation for this code is that our rules consist of membership numbers of functions derived from the previous function. And rule values as well.

The rules may have conflicts. So we use this code to delete the conflicted rules. This code is named as " ConflictChecking.m ".

```
k = 1;
    while ~isempty(Rule)
        First = repmat(Rule(1,1:end-1),
size(Rule,1),1);
        Rule_B = Rule(:,1:end-1);
        Index = Rule_B == First;
        Index = find(sum(Index,2) ==
numel(Rule_B(1,:)));

        [RuleDegree(k) Rule_Index] =
max(prod(Rule_MV(Index,:),2));

        Rule1(k,:) = Rule(Index(Rule_Index),:);
        Rule1MVlu(k,:) =
Rule_MV(Index(Rule_Index),:);
        k = k+1;
        m = 1;
        RuleBuffer = [];
```

```
        for n=1:size(Rule,1)
            if isempty(find(Index==n))
                RuleBuffer(m,:) = Rule(n,:);
                m = m+1;
            end
        end

        Rule = RuleBuffer;
    end
```

Here we calculate degrees of the rules by membership function values and by that we can detect and delete conflicted rules.

Fuzzy System

Now we have the rules, we form the rule base. And in the next step we create a fuzzy system with name of Time Series Prediction. A mamdani fuzzy system with MIE. Here is the code:

```
TSP = newfis('Time Series Prediction');
```

We should add Inputs and Outputs in a for loop with this code:

```
  TSP =
addvar(TSP,'input',Name,[LowBnd(i),UpBnd(i)]);

% For Triangular Membership Function.
            Step = (UpBnd(i)-LowBnd(i))/
(MemFuNu(i)-1);
            for j = 1:MemFuNu(i)
                Center = LowBnd(i)+(j-1)*Step;
                MemFName = [Name '_MF'
num2str(j)];
                TSP =
addmf(TSP,'input',i,MemFName,'trimf',[Center-
Step,Center,Center+Step]);
            end
```

And after all this we can add our rule base to the fuzzy system with this code:

```
TSP = addrule(TSP,RulesList);
```

Results

This is result of the program for this given parameters.

Fuzzy System detailes:

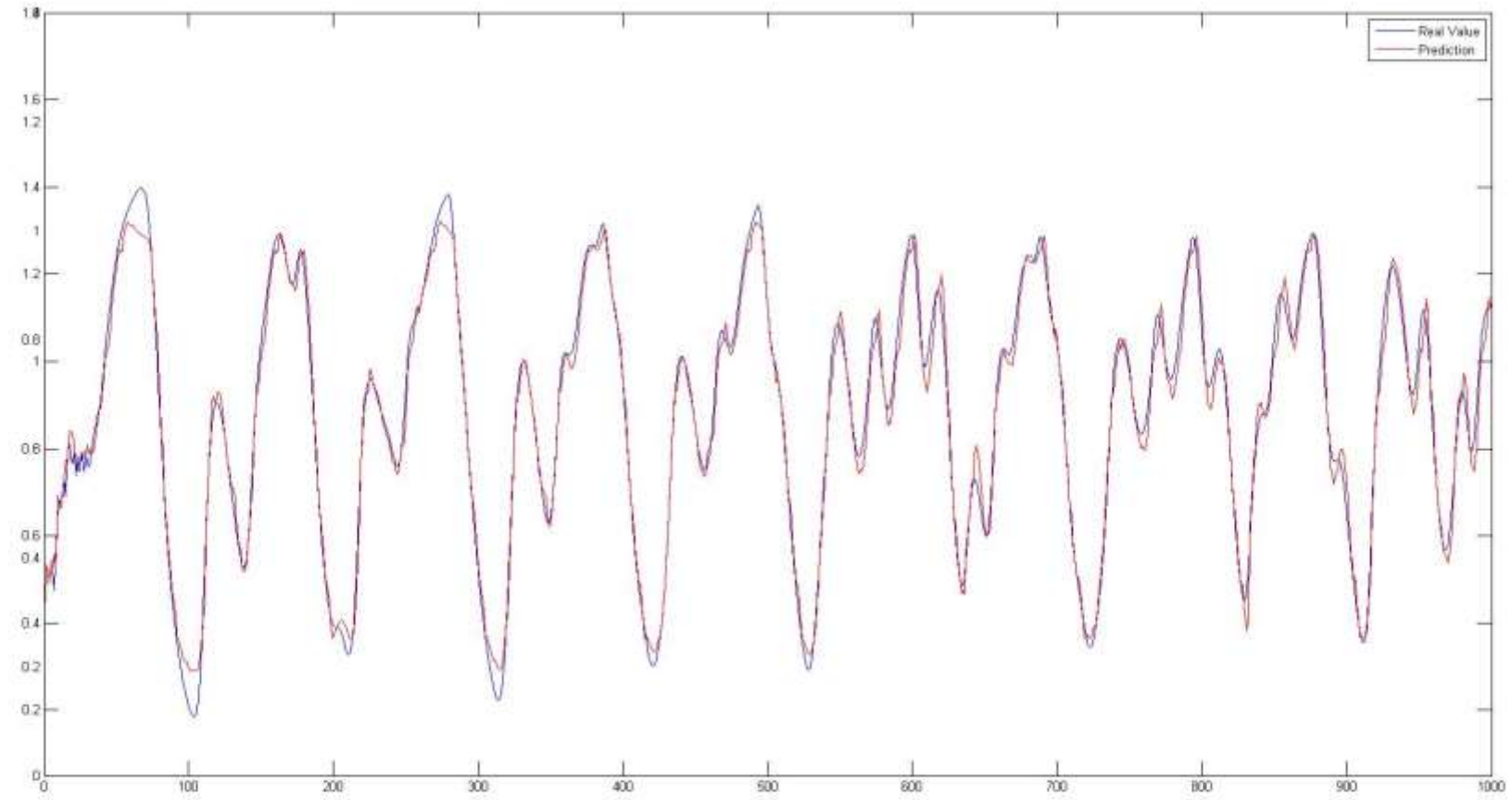
1. Name Time Series Prediction
2. Type mamdani
3. Inputs/Outputs [6 1]
4. NumInputMFs [18 18 18 18 18 18]
5. NumOutputMFs 18
6. NumRules 287
7. AndMethod min
8. OrMethod max
9. ImpMethod min
10. AggMethod max
11. DefuzzMethod centroid

Member ship Type: Gaussian

Number of All Rules: 500

Number of No Conflicting Rules: 287

Number of Conflicting Rules: 213



Error of Prediction = 0.26932%