

Solution to Problem 10

Task. Write a program that simulates fuzzy control with the three rules that we had in class:

- if ΔT is negligible, then u is negligible;
- if ΔT is small positive, then u is small negative;
- if ΔT is small negative, then u is small positive.

Your program should:

- input ΔT , and
- return the corresponding control $\bar{u}$.

Use separate methods for computing the corresponding membership functions, for computing the “and”-operation, and for computing the “or”-operation, so that if you will need to change one of these things, all you would have to do it replace the corresponding method without having to change the main method.

Test your program on the example of membership functions that we had in class and values $\Delta T = +3$ and $\Delta T = -3$. For each of these two values of ΔT , use your program to compute the resulting control value corresponding to the following two pairs of “and”- and “or”-operations: cases:

- “and”-operation is $\min(a, b)$ and “or”-operation is $\max(a, b)$;
- “and”-operation is $a \cdot b$ and “or”-operation is $a + b - a \cdot b$.

Solution.

```
public static double bar_u(double delta_T){
    double delta_u = 0.01;
    double num = 0.0;
    double den = 0.0;
    double u = -10.0;
    while(u <= 10.0)
        {num += u * mu(delta_T, u);
         den += mu(delta_T, u);
         u += delta_u;}
    return num/den;}
```

```

public static double mu(delta_T, double u){
    double r1 = f_and(mu_N(delta_T), mu_N(u));
    double r2 = f_and(mu_SP(delta_T), mu_SN(u));
    double r3 = f_and(mu_SN(delta_T), mu_SP(u));
    return f_or(r1, f_or(r2,r3));}

public static double mu_N(double x){
    if(0 <= x && x <= 5){return 1 - x/5;}
    elseif (-5 <= x && x <= 0) {return 1 + x/5;}
    else{return 0;}}

public static double mu_SP(double x){
    if(0 <= x && x <= 5){return x/5;}
    elseif(5 <= x && x <= 10){return 2.0 - x/5;}
    else{return 0;}}

public static double mu_SN(double x){
    if(-5 <= x && x <= 0){return -x/5;}
    elseif(-10 <= x && x <= -5){return 2.0 + x/5;}
    else{return 0;}}

public static double f_and(double a, double b){
    return Math.min(a,b);}

public static double f_or(double a, double b){
    return Math.max(a,b);}

public static void main(String[] args){
    Scanner read = new Scanner(System.in);
    System.out.println("Enter the difference between" +
        "the actual and the desired temperatures");
    double delta_T = read.nextDouble();
    System.out.println("For Delta T = ", delta_T, ", use control u = ", bar_u(delta_T));
}

```

To apply $a \cdot b$ and $a + b - a \cdot b$, replace the methods for computing “and”- and “or”-operations with the following ones:

```

public static double f_and(double a, double b){
    return a * b;}

public static double f_or(double a, double b){
    return a + b - a * b;}

```