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function fY = fitnessFunctionff(vg,crossOverChromosome)
% THIS FUNCTION CALCULATES THE FITNESS FUNCTION f(Y) DESIGN
% MEASURE. THIS FUNCTION SHOULD BE USED THROUGH THE BILEVEL OPTIMIZATION
% ALONG WITH THE FIRST FITNESS FUNCTION F(X)
% FOR THE FORMULA, SEE EQUATION 9
%
% INPUT:  [NxN DOUBLE]  CCF ARRAY DEFINED AS  $v^g$  IN THE EQUATION
%         [MxN DOUBLE]  ARRAY OF LLCs FOR EACH ULC MODULE
%
% OUTPUT: [1x1 DOUBLE]  FITNESS f(Y) DESIGN MEASURE
%
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%
% PROJECT: ME 6101 GREEN MODULAR DESIGN GROUP PROJECT
% DATE: NOVEMBER 2017
% LOCATION: GEORGIA INSTITUTE OF TECHNOLOGY. ATL, GA
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[FNT1,mk] = ffNumerator1(vg,crossOverChromosome);
[FNT2,~] = ffNumerator2(vg,crossOverChromosome);
m = max(max(crossOverChromosome));

denom = 0;
for i=1:1:m
    denom = denom + mk;
end

fY=(FNT1-FNT2)/denom;

end

function [ffNumeratorTerm1,mk] = ffNumerator1(vg,crossOverChromosome)
% THIS FUNCTION CALCULATES THE FIRST NUMERATOR TERM OF THE f(Y) DESIGN
% MEASURE. THIS FUNCTION ALONG WITH ffNumerator2 SHOULD BE USED THROUGH THE
% BILEVEL OPTIMIZATION
% FOR THE FORMULA, SEE EQUATION 9
%
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% SETTING THE COMPONENT NUMBER
n=22;
% DECLARING ITERATION VARIABLES
ffNumeratorTerm1=0;
numo=0;
denom=0;
% SORT THE INPUT INTO A R3 BINARY ARRAY
[binChromArray,mk] = chromoSortMultiDim(crossOverChromosome);
% ISOLATE THE LARGEST ELEMENT VALUE AS m
[ym,~] = size(crossOverChromosome);

% STARTING FIRST, EXTERIOR SUMMATION FOR LOOP
for k = 1:1:ym

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[~,~,mk,~] = chromoSort(crossOverChromosome(k,:));
for j=1:1:mk
    chkVec = sum(binChromArray(k,j,:));
    if chkVec~=0

        % TWO NESTED SUMMATION THAT MAKE UP THE NUMERATOR FOR THE TERM
        for i=1:1:n
            for l=1:1:n
                % PRODUCT OF INDEXED VALUES ON THE NUMERATOR
                % INCLUDED IN THE DOUBLE SUMMATION
                v1=vg(i,l);
                y1=binChromArray(k,j,i);
                y2=binChromArray(k,j,l);
                numo=numo+(y1*y2*v1);
            end
        end

        % THIS BLOCK DEFINES THE SQUARED
        % SUMMATION TERM IN THE DENOMINATOR
        for l=1:1:n
            denom=denom+binChromArray(k,j,l);
        end
        denom=(denom)^2;
        % EXTERNAL SUMMATION
        ffNumeratorTerm1=ffNumeratorTerm1+(numo/denom);
        numo=0;
        denom=0;
    end
end
end
end

function [ffNumeratorTerm2,mk] = ffNumerator2(vg,crossOverChromosome)
% THIS FUNCTION CALCULATES THE FIRST NUMERATOR TERM OF THE f(Y) DESIGN
% MEASURE. THIS FUNCTION ALONG WITH ffNumerator2 SHOULD BE USED THROUGH THE
% BILEVEL OPTIMIZATION
% FOR THE FORMULA, SEE EQUATION 9
%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% SETTING THE COMPONENT NUMBER
n=22;
% DECLARING ITERATION VARIABLES
ffNumeratorTerm2=0;
numo=0;
denom=0;

% SORT THE INPUT INTO A R3 BINARY ARRAY
[binChromArray,mk] = chromoSortMultiDim(crossOverChromosome);
% ISOLATE THE LARGEST ELEMENT VALUE AS m
[ym,~] = size(crossOverChromosome);

% STARTING FIRST, EXTERIOR SUMMATION FOR LOOP
for k = 1:1:ym

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for j=1:1:mk
    chkVec = sum(binChromArray(k,j,:));
    if chkVec~=0
        % TWO NESTED SUMMATION THAT MAKE UP THE NUMERATOR FOR THE TERM
        for i=1:1:n
            for l=1:1:n
                % PRODUCT OF INDEXED VALUES ON THE NUMERATOR
                % INCLUDED IN THE DOUBLE SUMMATION
                v1=vg(i,l);
                y1=binChromArray(k,j,i);
                y2=abs(1-binChromArray(k,j,l));
                numo=numo+(y1*y2*v1);
            end
        end
        % THIS BLOCK DEFINES THE SQUARED
        % SUMMATION TERM IN THE DENOMINATOR
        for l=1:1:n
            denom=denom+binChromArray(k,j,l);
        end
        denom=(n-denom)^2;
        % EXTERNAL SUMMATION
        ffNumeratorTerm2=ffNumeratorTerm2+(numo/denom);
        denom=0;
        numo=0;
    end
end
end
end
end

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