**嵌入式視覺HW1**

**Image Enhancement algorithms**

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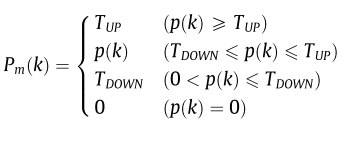
學生：張翔珳

**1.實作論文**

　　A new adaptive contrast enhancement algorithm for infrared images based on double plateaus histogram equalization[1]，一種自適應雙門檻直方圖均勻化的方法，並以此論文練習GRAFCET建模，將其軟體高階合成。

**2.論文方法**

　　利用上界和下界去過濾直方圖，pseudo code如下



P(k): 直方圖灰階k的出現次數

Tup: 上界

Tdown: 下界

Pm: 修改後的直方圖

　　Tup上界門檻值是取直方圖所有local maximum的平均值，而local maximum是利用一維遮罩去過濾直方圖，當遮罩中心值為最大值時，便將它納入local maximum的group。

　　Tdown下界公式如下所示

Tdown = min(Ntotal, Tup \* L)/M

其中M為灰階數量256, Ntotal為原始影像像素數量, L為直方圖像素非零值的數量。

　　上界可以確保影像不會over-equalization，而下界則可以確保不會損失影像細節，不會將過低的灰階值給納入合併成相同灰階值，進而降低影像品質

**3.IDEF0系統架構和GRAFCET建模**

　　整體影像增強系統架構可分為四個模組，一為從鍵盤輸入檔案名稱，二為讀取輸入影像，三為影像增強演算法，四為輸出影像至檔案系統。並使用MIAT方法論對系統建模，如下圖所示。



影像增強系統top Grafcet如下圖所示：



灰階數量M=256，1維遮罩大小WIN\_SIZE=9，WIN\_SIZE\_2=WIN\_SIZE>>1



|  |  |  |
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| 狀態 | 動作 | 功能說明 |
| 20 | //Initial histogram bin to zero  for(int z=0;z < M;z++)bin[z]=0  i=j=0 | 直方圖和影像座標初始化 |
| 21 | //read image pixels  pixel = ima(i, j)  if(j == nc - 1) i++, j=0; else j++; | 取得影像對應座標像素  座標遞增 |
| 22 | //statistics histogram  bin[pixel]++ | 統計直方圖 |
| 23 | first\_one = last\_two = last\_one = -1;  bi=255; fi=0; head=0;  for(z = 0;z < WIN\_SIZE;z++)  　buf[i] = 0;  nz\_cnt=0;  max\_sum=0; max\_cnt=0; | 各項參數初始化：  SHE參數  ADPHE參數 |
| 24 | if(bin[bi]&&last\_one<0)  last\_one=bi;  elsif(bin[bi]&&last\_two<0) last\_two=bi;  bi--; | 找直方圖最後一個和倒數第二個非零的灰階索引值 |
| 25 | if(bin[fi] && first\_one < 0) first\_one=fi; | 找直方圖第一個  非零的灰階索引值 |
| 26 | //get local max sum  buf[head]=bin[fi];  max\_sum+=lmax(buf);  max\_cnt+=(buf[WIN\_SIZE\_2] >= max) ? 1 : 0;  head=(head+1)%WIN\_SIZE; | 統計直方圖  區域最大值的平均值 |
| 27 | //non-zero count  if(bin[fi++]) nz\_cnt++; | 統計直方圖出現次數  非零的數量 |
| 28 | //threshold calculation  Tup=max\_sum/(max\_cnt+1)  Tdown=min(nr \* nc, Tup\*nz\_cnt)/(M<<1)  index=1; N=0; i=0; j=0;  bin[first\_one]=0; bin[last\_one]=bin[last\_two]; | 計算  自適應上界、下界門檻值  取代第一個出現的灰階次數為0  將倒數第一個的數量取代為倒數第二個的數量 |
| 29 | //threshold histogram  z:=index; temp:=bin[z];  if(bin[z] >=Tup)  　temp:=Tup;  elsif(bin[z]==0) temp:=0;  elsif (bin[z]<=Tdown)  　temp:=Tdown; | 根據上界、下界  門檻化直方圖 |
| 210 | //accumulative  bin[z]=temp + bin[z-1];  N+=temp;  index++; | 累加直方圖出現次數 |
| 211 | //LUT output  bima[i][j]=bin[ima[i][j]] \* (M-1) / N;  if(j == nc - 1){  i++; j = 0;  }else j++; | 以輸入影像對  直方圖查表數值  至輸出影像 |
| 212 | NULL | 上層模組轉移空狀態 |

**4.軟體高階合成**

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| --- |
| **#include <iostream>**  **#include "stdlib.h"**  **#include "bmp.h"**  **#define M 256**  **#define WIN\_SIZE 9**  **#define WIN\_SIZE\_2 (WIN\_SIZE >> 1)**  **using namespace std;**  **//global variable**  **int bin[M];**  **unsigned char \*\*ima, \*\*bima;**  **int nr, nc;//image height and width**  **int fi, i, j;**  **int index, N;**  **char filename[128];**  **bool isvalid;**  **//state**  **int x0 = 1, x1, x2, x3, x4;**  **int x20 = 1,x21 ,x22 ,x23 ,x24 ,x25 ,x26 ,x27 ,x28 ,x29 ,x210 ,x211, x212;**  **void grafcet0();**  **void action0();**  **void grafcet1\_ADPHE\_SHE();**  **void action1();**  **int main(int argc, char\*\* argv) {**    **while(x4 != 1) grafcet0();**  **system("PAUSE");**  **return 1;**  **}**  **void grafcet0(){**    **action0();**  **if(x0 == 1){ x0 = 0; x1 = 1;}**  **else if(x1 == 1){ x1 = 0; x2 = 1;}**  **else if(x2 == 1 && x212 == 1){ x2 = 0; x3 = 1;}**  **else if(x3 == 1){ x3 = 0; x4 = 1;}**  **else if(x4 == 1){ x4 = 0; x0 = 1;}**  **}**  **void action0(){**  **if(x0 == 1){**  **isvalid = false;**  **//read bmp image from file**  **cout << "Enter input filename:";**  **cin >> filename;**  **}**  **else if(x1 == 1){**  **isvalid = Read\_BMP(filename, ima, nr, nc);**  **if (!isvalid) exit(1);**  **bima=UC2D(nr, nc);**  **Write\_BMP\_8bits("ima.bmp", ima, nr, nc);**  **}**  **else if(x2 == 1){ grafcet1\_ADPHE\_SHE(); }**  **else if(x3 == 1){ Write\_BMP\_8bits("ADPHE\_SHE.bmp", bima, nr, nc); }**  **}**  **void grafcet1\_ADPHE\_SHE(){**  **action1();**  **if(x20 == 1){x20 = 0; x21 = 1; x22 = 1;}**  **else if(x21 == 1 && x22 == 1 && i == nr){x21 = 0; x22 = 0; x23 = 1;}**  **else if(x23 == 1){x23 = 0; x24 = 1; x25 = 1; x26 = 1; x27 = 1;}**  **else if(x24 == 1 && x25 == 1 && x26 == 1 && x27 == 1 && fi == M){x24 = 0; x25 = 0; x26 = 0; x27 = 0; x28 = 1;}**  **else if(x28 == 1){x28 = 0; x29 = 1; x210 = 1;}**  **else if(x29 == 1 && x210 == 1 && index == M){x29 = 0; x210 = 0; x211 = 1;}**  **else if(x211 == 1 && i == nr){x211 = 0; x212 = 1;}**  **else if(x212 == 1){x212 = 0; x20 = 1;}**  **}**  **void action1(){**  **static int first\_one, last\_two, last\_one, head, nz\_cnt, max\_sum, max\_cnt, bi;**  **static int Tup, Tdown;**  **static int buf[WIN\_SIZE];**  **int z, temp;**  **int pixel;**    **if(x20 == 1){ i = j = 0; for(int index = 0;index < M;index++) bin[index] = 0;}**  **if(x21 == 1){ pixel = ima[i][j]; if(j == nc - 1) i++, j=0; else j++;}**  **if(x22 == 1){ bin[pixel]++;}**  **if(x23 == 1){**  **for(int z = 0;z < WIN\_SIZE;z++) buf[z] = 0;**  **first\_one = last\_two = last\_one = -1; head = fi = nz\_cnt = max\_sum = max\_cnt = 0;**  **bi = M - 1;**  **}**  **if(x24 == 1){**  **if(bin[bi] && last\_one < 0) last\_one = bi;**  **else if(bin[bi] && last\_two < 0) last\_two = bi;**  **bi--;**  **}**  **if(x25 == 1){**  **if(bin[fi] && first\_one < 0) first\_one = fi;**  **}**  **if(x26 == 1){**  **buf[head] = bin[fi];**  **//lmax**  **int max = buf[0];**  **for(int z = 1;z < WIN\_SIZE;z++)**  **if(max < buf[z]) max = buf[z];**  **max\_sum += ((buf[WIN\_SIZE\_2] >= max) ? buf[WIN\_SIZE\_2] : 0);**  **max\_cnt += ((buf[WIN\_SIZE\_2] >= max) ? 1 : 0);**    **head = (head + 1) % WIN\_SIZE;**  **}**  **if(x27 == 1){**  **if(bin[fi]) nz\_cnt++;**  **fi++;**  **}**  **if(x28 == 1){**  **Tup = max\_sum/(max\_cnt+1);**  **int temp1, temp2;**  **temp1 = nr \* nc; temp2 = Tup \* nz\_cnt;**  **Tdown = ((temp1 > temp2) ? temp2 : temp1) / (M << 1);**  **index = 1; N = i = j = 0;**  **bin[first\_one] = 0; bin[last\_one] = bin[last\_two];**  **}**  **if(x29 == 1){**  **z = index; temp = bin[z];**  **if(bin[z] >= Tup) temp = Tup;**  **else if(bin[z] == 0) temp = 0;**  **else if(bin[z] <= Tdown) temp = Tdown;**  **}**  **if(x210 == 1){**  **bin[z] = temp + bin[z - 1];**  **N += temp;**  **index++;**  **}**  **if(x211 == 1){**  **bima[i][j] = bin[ima[i][j]] \* (M - 1) / (N);**  **if(j == nc - 1){ i++, j = 0;}**  **else j++;**  **}**  **if(x212 == 1){ /\*no operation\*/ }**    **}** |

**5.實驗結果**

　　透過實驗數張影像發現Tdown的公式導致Tdown數值過高，容易造成直方圖均勻化時沒有效果，所以可改為除2，如下所示

Tdown = min(Ntotal, Tup \* L)/(2\*M)

HE(Standard Histogram equalization)

ADPHE(Adaptive Double plateau histogram equalization)[1]

SHE(A simple histogram modification scheme for contrast enhancement)[3]

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| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Position3_8bit.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Position3_8bit-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Position3_8bit-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Position3_8bit-processed.bmp |
| 原圖 | HE | SHE | ADPHE and SHE |
| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Rectangular1_8bit.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Rectangular1_8bit-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Rectangular1_8bit-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Rectangular1_8bit-processed.bmp |
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| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Rectangular4_8bit.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Rectangular4_8bit-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Rectangular4_8bit-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Rectangular4_8bit-processed.bmp |
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| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Surrounded_8bit.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Surrounded_8bit-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Surrounded_8bit-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\Surrounded_8bit-processed.bmp |
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| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\TestTube001_8bit.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\TestTube001_8bit-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\TestTube001_8bit-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\TestTube001_8bit-processed.bmp |
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| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\UniSiegen_8bit.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\UniSiegen_8bit-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\UniSiegen_8bit-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\ADLink_with_Tdown\UniSiegen_8bit-processed.bmp |
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| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\CR.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\CR-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\CR-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\CR-processed.bmp |
| 原圖 | HE | SHE | ADPHE and SHE |
| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\dark.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\dark-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\dark-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\dark-processed.bmp |
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| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\DPHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\DPHE-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\DPHE-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\DPHE-processed.bmp |
| 原圖 | HE | SHE | ADPHE and SHE |
| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\explosion.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\explosion-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\explosion-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\explosion-processed.bmp |
| 原圖 | HE | SHE | ADPHE and SHE |
| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\FigP0438(left).bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\FigP0438(left)-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\FigP0438(left)-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\FigP0438(left)-processed.bmp |
| 原圖 | HE | SHE | ADPHE and SHE |
| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\hands3.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\hands3-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\hands3-processed.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\hands3-SHE.bmp |
| 原圖 | HE | SHE | ADPHE and SHE |
| C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\women.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\women-HE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\women-SHE.bmp | C:\Users\MIAT\Desktop\MIAT\1051master\Embedded_vision\HW1\DevC++\women-processed.bmp |
| 原圖 | HE | SHE | ADPHE and SHE |

**6.參考資料：**

[1] Liang et al. “A new adaptive contrast enhancement algorithm for infrared images based on double plateaus histogram equalization”

[2] 陳慶瀚教授 “MIAT技術文件\_微程式控制器設計與硬體合成”

[3] Chang et al. “A simple histogram modification scheme for contrast enhancement”