CmpE240

F2023

Nov. 6th (Monday).

Note1. Midterm Exam is scheduled on Next Monday.

Review Session in-class is scheduled on Wednesday.

Today's Topics:

1° SSPInit Code.

2° Hardware Design for LCD/CPU Interface Design.

Example: Line 210-246.

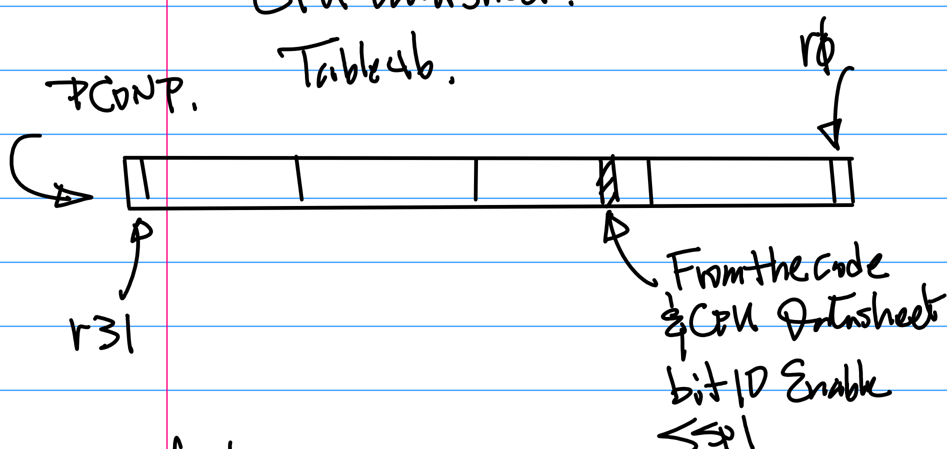
Line 224 Naming Convention

LPC_SC -> PCONP

Section 4.8.5. pp61

CPU Datasheet.

Table 46.



Line 227.

LPC_SC -> PCLKSEL

Line 229

Line 230

LPC_SC -> PINSEL0.

pp.58, Table 42.

Section 4.7.3. pp57.

Note: Draw a 32Bit SPR illustration.

Connect to CPU Datasheet (Tables for the SPR).

The memory Bank holding this SPR.

Code Implementation.

Note: The Sequence to Init & Config SPRs for SSP Interface. (SPI)

PCONP -> PCKSEL -> PINSEL0

Line 233/234 CS (Chip select: e.g. Select/Enable my LCD Display module)

Line 238

SSP1 CR0.

pp.431. Table 371

Use Case Leads to Design Requirements, for Example, 2D G.E. Design. Frame Rate, Resolution of the Display ->

Carry out the Design By Using CPU Datasheet, and formula

$$f_{PWM} = \frac{PCLK}{CPSDVSR * (SCR+1)}.$$

then, Coding.

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Homework: Due Nov. 19th (Sunday).

1° Requirements:

a) Based on the Homework of Drawing A Wireframe Cube in X_w-Y_w-Z_w, Add a point light source, such as

$\vec{P_s}(x_s, y_s, z_s) = (-5, 50, 250)$,

b) Use the vertices from the Top Surface of the cube to generate 4 Ray Equations, then Compute the intersection Points on X_w-Y_w plane

Note: Computation is Carried out Before the Transformation pipeline, e.g., in X_w-Y_w-Z_w Coordinate.

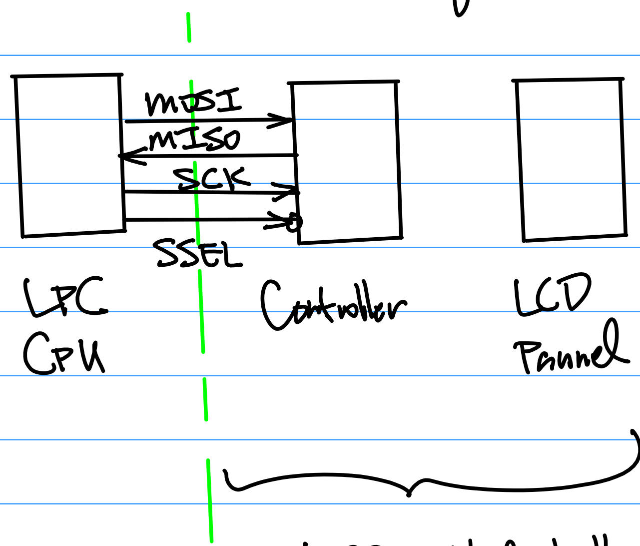
c) Draw the shadow first Before Drawing the Cube.

Note: Design/Select A proper dark color for the shadow.

Note: please work/Discuss this homework with your team. But coding has to Be individually, No code Can be shared.

Note: Please Bring Your Board for show & Tell, Demo ON Monday. Nov. 20 (monday).

Consider Hardware Design for LCD Controller Interface.



LCD with Controller Build IN.

Note: please provide Clear indication of the Signal Flow By Drawing Arrow ON Each Signal line.

Also, place a circle "o" for Active Low Signal.

Nov. 8 (Wed)

Note 1. Midterm Exam is Next Monday.

a) Please Bring your Prototype System;

b) Bring Blank Papers for the exam hand Calculation;

Homework

c) use "printf" to print your First Name, Last Name and SID, while executing Program During the example.

d) There are 3 Questions.

Question in the CPU Architecture, memory, SPRs. Memory Bank,

Question on the subject of Building A prototype System. SCH, pin Connectors, functionality of the pins. and interface to LCD.

Question in the Area Design. Debugging, hand Calculation.

e) Naming Convention of the Zip.

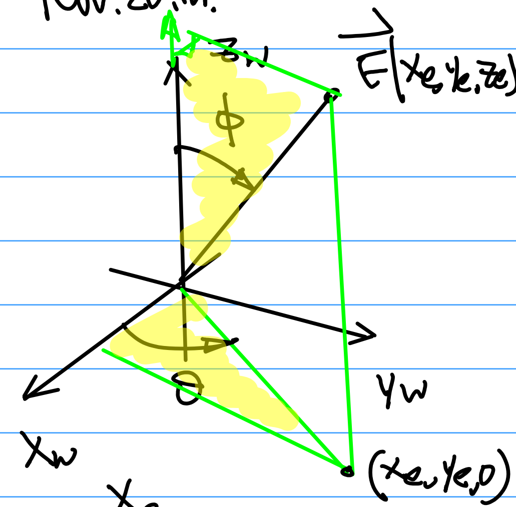
FirstName_LastName_SID_Cmpe240_mid.zip

One pdf (integration of All pdf files)

f) Resolution of the photos. Not too high, Not too low Resolution, 1 ~ 4 MB.

g) Submission on CANVAS. No Late Submission, No E-mail Submission

Note: Shadow Computation Due Nov 19 (Sun). Please Bring your Board for Demo on Monday. Nov. 20 th.



$$\cos\theta = \frac{x_e}{\sqrt{x_e^2+y_e^2}}$$

$\sin\theta$

$$\cos\phi = \frac{z_e}{\rho} = \frac{z_e}{\sqrt{x_e^2+y_e^2+z_e^2}}$$

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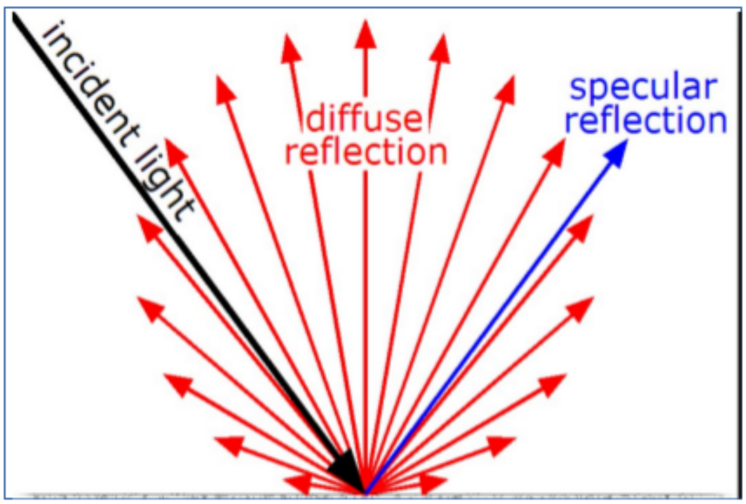
F2023 Part II 54

Nov.15 (Wed).

Ref: Pp.1. Definition/Concept of Diffuse Reflection.

2018S-23-lec7-DiffuseReflection-v6-2018-4-25.pdf

Diffuse Reflection



https://en.wikipedia.org/wiki/Diffuse_reflection

Diffuse Reflection: the reflection of light uniformly in all different directions, the surface of this reflection exhibits Lambert reflection, e.g., equal luminance when viewed from all directions.

Two Key Characteristics:

1. The surface with reflectivity as K_d = (k_r, k_g, k_b), e.g., diffuse coefficients;

2. The decay of incident light is inverse proportional to its distance from the source to the surface point. e.g., 1/(r*r), where r is bing the distance from the light source to the surface.

Specular vs. diffuse reflection

Harry Li, Ph.D.

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Nov.14,22 47

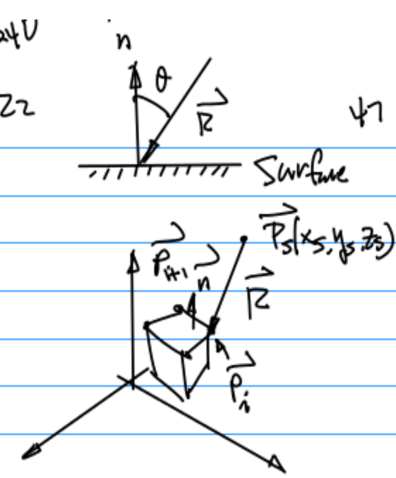


Fig.1.

Note;

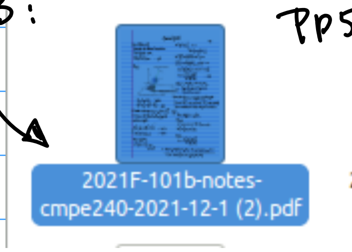
1° Definition: PP.54. Reflection Uniformally in All different directions.

Ref2: on the Class github.

2022F-101-notes-cmpe240-2022-11-30 (1).pdf

Example: Background on Diffuse Reflection.

Ref3: Pp54.



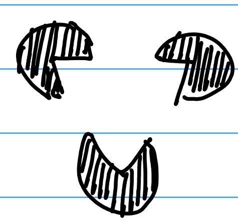


Fig.2

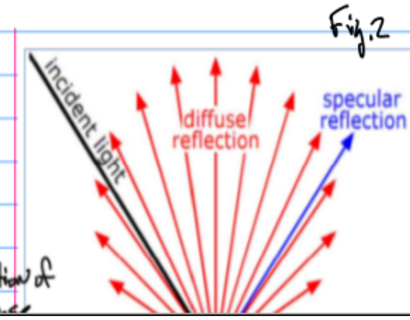


Illustration of Diffuse

Brief Introduction, And 3 Lighting models.

Three models. see Ref3. pp.54

$$I(x,y) = I_1(x,y) + I_2(x,y) + I_3(x,y)$$

Diffuse Reflection   Specular Reflection   Ambient Light

Note: Specular ... (2)

Definition of Diffuse Reflection.
Ref.1. P81.

Reflection Uniformly Reflects the Incoming light in All Different Direction.

Note1. $\vec{P_s}(x_s, y_s, z_s)$ Incident Light, White Color.
for example
$r=g=b=255$

Diffuse Reflection

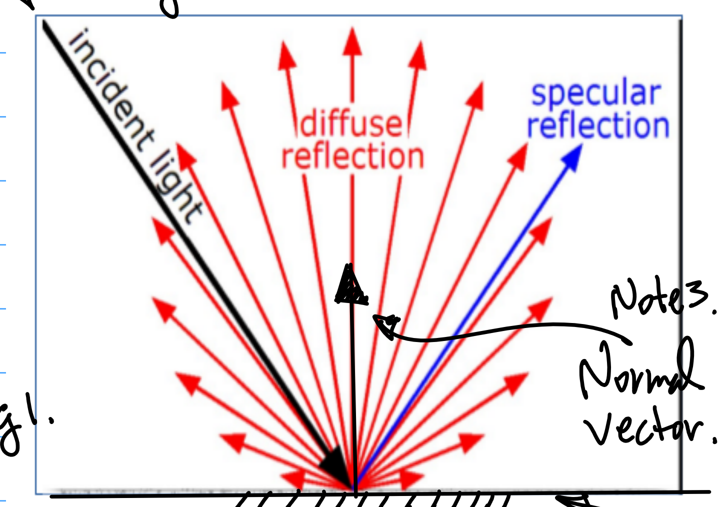


Fig1.

https://en.wikipedia.org/wiki/Diffuse_reflection

Color of A surface: physical Characteristic.

Definition of Reflectivity to Describe

the Characteristics of A surface Color.

Reflection of the color leads to the perception of the color.

Two Key Characteristics:

1. The surface with reflectivity as K_d = (k_r, k_g, k_b), e.g., diffuse coefficients; ... (1)

diffuse Reflection

2. The decay of incident light is inverse proportional to its distance from the source to the surface point. e.g., 1/(r*r), where r is bing the distance from the light source to the surface.

Specular vs. diffuse reflection

where K_r: Reflectivity for red

K_g: " " green

K_b: " " blue

Normalized, so

$$K_r \in [0,1],$$
$$K_g, K_b \in [0,1] \quad ..(2)$$

for Example for the Blue Chair,

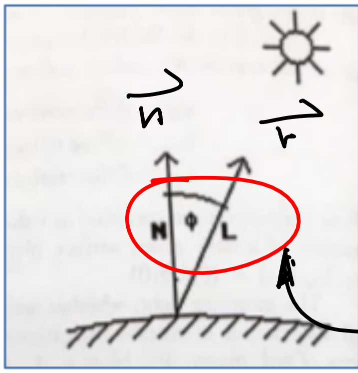
$$K_r = 0, K_g = 0, 0 < K_b < 1$$

Consider the Normal $\vec{n}$ and its Angle formed by the incident light

PP.3. Ref. 1.

e, then

(x,y,z) can



Reference: Computer Graphics, C. K. Pokorny, C. F. Gerald, pp. 514

TP.3. Ref.1.

Note 1. Regarding Angle ϕ

$$\boxed{I_r = K_{d_r} \frac{\vec{n} \cdot \vec{r}}{\|\vec{n}\| \|\vec{r}\|} \frac{1}{\|\vec{r}\|_2^2}} \quad \ldots (1.1)$$

where

$$\boxed{\|\vec{r}\|_2^2 = x_r^2 + y_r^2 + z_r^2}$$

$$\boxed{I_g = K_{d_g} \frac{\vec{n} \cdot \vec{r}}{\|\vec{n}\| \|\vec{r}\|} \cdot \frac{1}{\|\vec{r}\|_2^2}} \quad \ldots (1.2)$$

$$\boxed{I_b = K_{d_b} \frac{\vec{n} \cdot \vec{r}}{\|\vec{n}\| \|\vec{r}\|} \cdot \frac{1}{\|\vec{r}\|_2^2}} \quad \ldots (1.3)$$

Use Vector Dot Product.

$\vec{n}$: Normal Vector.

$\vec{r}$: Ray Equation (Reformulated). To Point to $\vec{P_s}$, to get rid of Negative Sign.)

$$\vec{n} \cdot \vec{r} = \|\vec{n}\| \|\vec{r}\| \cos\phi \quad \ldots (3)$$

$$\cos\phi = \frac{\vec{n} \cdot \vec{r}}{\|\vec{n}\| \|\vec{r}\|}$$

$$\phi = \cos^{-1}\left(\frac{\vec{n} \cdot \vec{r}}{\|\vec{n}\| \|\vec{r}\|}\right)$$

Instead, use $\cos\phi$.

$$I_d(x, y) \sim K_d \cos\phi$$

$$= K_d \frac{\vec{n} \cdot \vec{r}}{\|\vec{n}\| \|\vec{r}\|} \quad \ldots (4)$$

intermediate Result in Eqn (4).

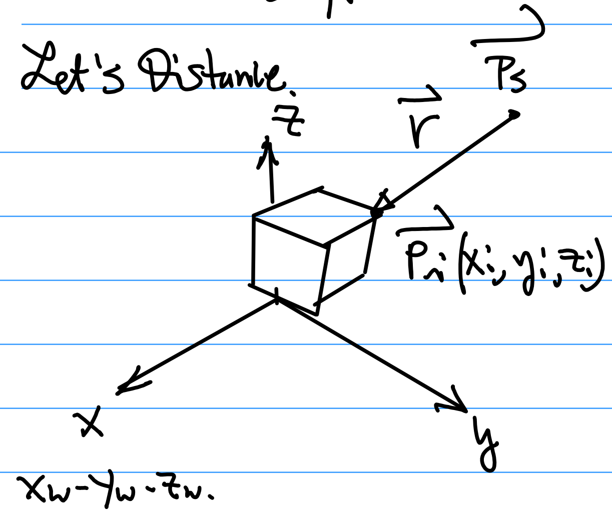
Nov. 20 (Monday)

Ref:

2021F-101b-notes-cmpe240-2021-12-1 (1).pdf

Example: Add Distance factor into Eqn (4), e.g., the shorter distance gives stronger Color intensity.

Let's Distance.



distance,

$$\|\vec{r}\| = \sqrt{(x_s-x_i)^2+(y_s-y_i)^2+(z_s-z_i)^2} \quad \cdots (1)$$

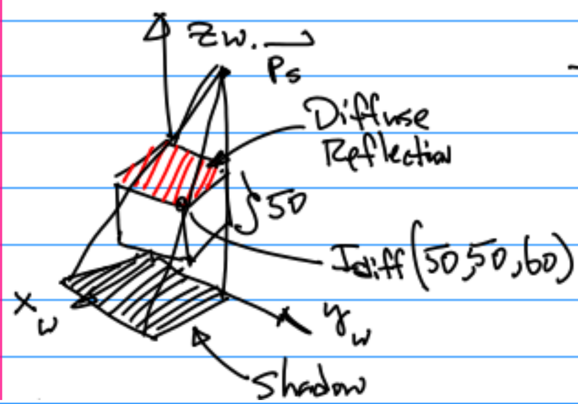
$$I_{diff}(x,y,z) = K_d \frac{\vec{n}\cdot\vec{r}}{\|\vec{n}\|\|\vec{r}\|} \cdot \frac{1}{\|\vec{r}\|^2} \quad \cdots (5)$$

Note: from the Ref. Hand Calculation.

Hence:

$$\boxed{\vec{I}_{diff} = K_d \cdot \frac{1}{\|\vec{r}\|^2} \cdot \cos\alpha = K_d \cdot \frac{1}{\|\vec{r}\|^2} \cdot \frac{\vec{n}\cdot\vec{r}}{\|\vec{n}\|\|\vec{r}\|}} \quad \cdots (4)$$

Example: Given Conditions



CmpE240(II)

$(50,50,60)-(40,60,120) = (10,-10,-60)$ 57

$\vec{r} = \vec{P_i} + \lambda(\vec{P_s} - \vec{P_i})$! for this Calculation

$= (50,50,60) + \lambda((40,60,120)-(50,50,60))$

$= (50,50,60) + \lambda(-10,10,60)$

Let $\lambda=1$. $\vec{r}|_{\lambda=1} = (50,50,60)+(-10,10,60)$

$= (40,60,120)$

$\vec{n}\cdot\vec{r} = (0,0,1)\cdot(40,60,120) = \cancel{0\times40} + \cancel{0\times60} + 1\times120 = 120$

$$\frac{\vec{n}\cdot\vec{r}}{\|\vec{n}\|\|\vec{r}\|} = \frac{120}{1\cdot\sqrt{40^2+60^2+120^2}} = \frac{120}{\sqrt{40^2+60^2+120^2}}$$

Therefore,

Note 1. Diffuse Reflection Result is very Small Due to $\frac{1}{\|\vec{r}\|^2}$, in the coding, add offset, constant to make it Visible, such as 20 to 40. $\in [0, 255]$.

Sample code is on the github.

Keyword " diffuse ... .cpp"
2018F-11b ~

Now, Consider Engineering Implementation.

Condition:

4 Vertices' color has been Computed in X_w-Y_w-Z_w.

Now, Consider Computation After Perspective Projection

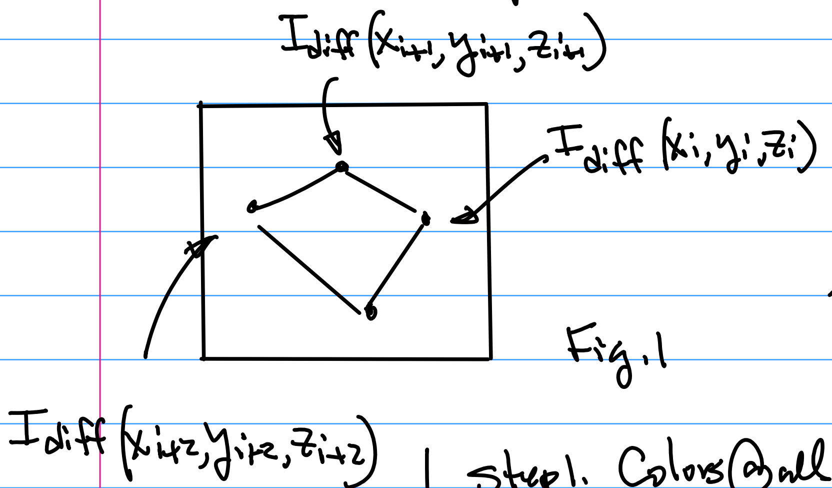


Fig.1

↓ Step 1. Colors @ all, Find Boundaries

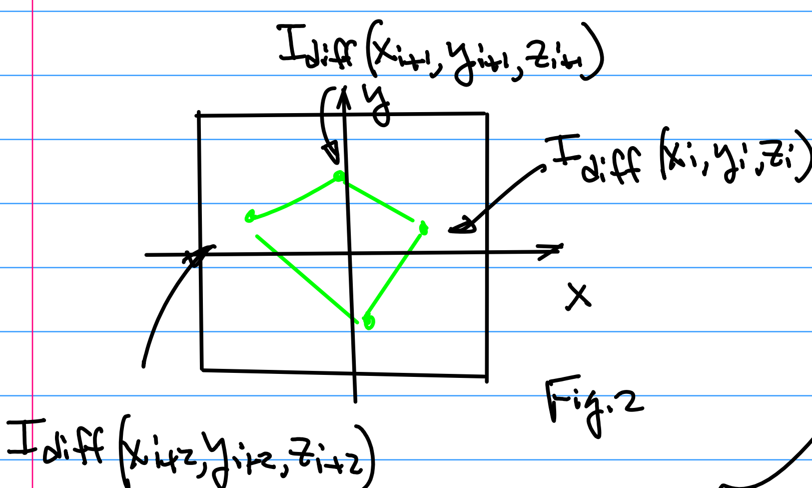


Fig.2

↓ Step 2.

Find colors for all the interior Points

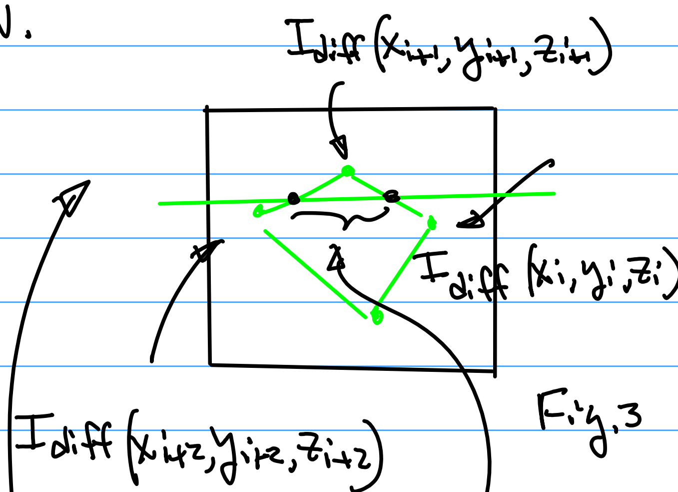


Fig.3

All Colors on this line (Arbitrary line)

Example: For Step 1.

Given 2 points of Diffuse Reflection colour, Find all colors on this Line.

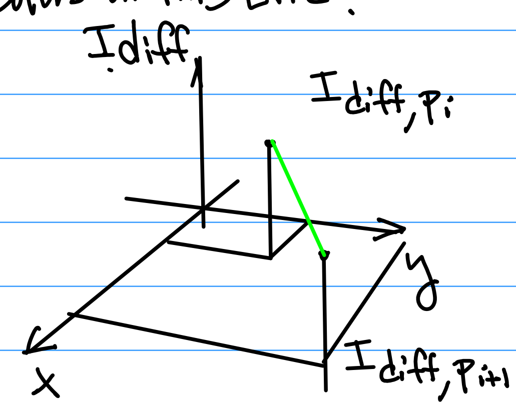
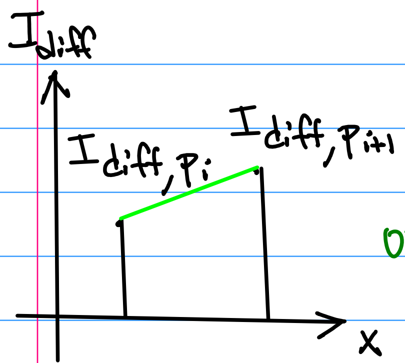


Fig.4

Fig.4

Projection to x-Idiff



OR

Fig5

Use Linear Interpolation to find the Color of each and every point on this line.

for example: for (x', y') find its color.

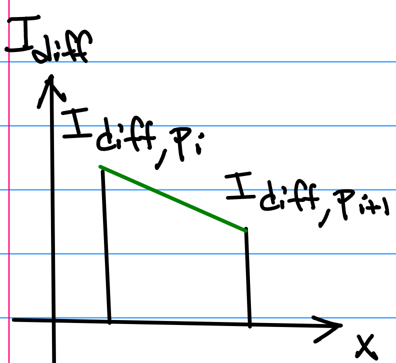


Fig.6

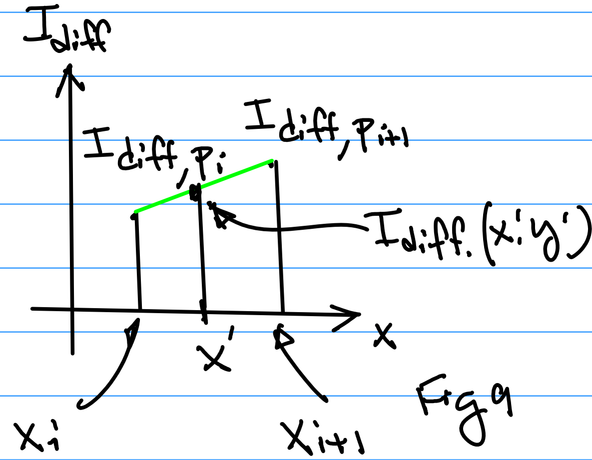
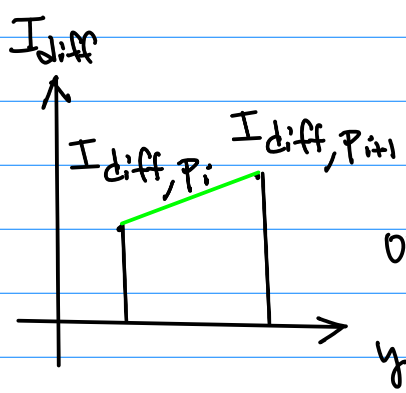


Fig9

Similarly, Projection for y.

And for y.



OR

Fig7

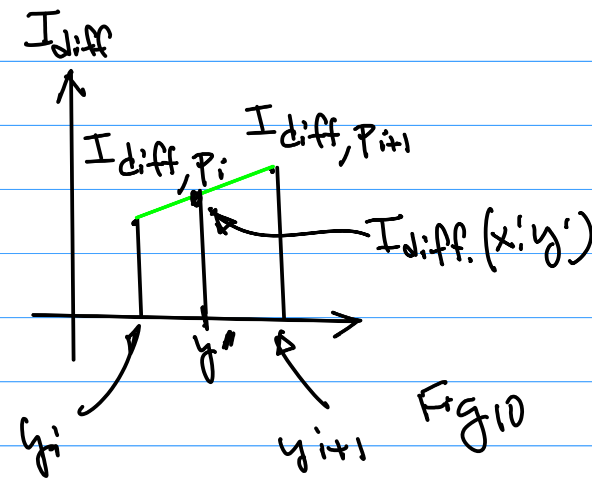


Fig10

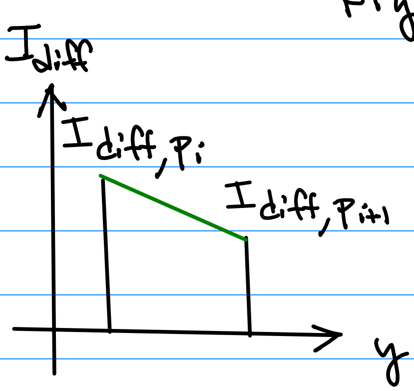


Fig.8

To Combine them

Final Dec.13(Wed) 12:15-2:30pm.

$$\begin{pmatrix}\text{Diffuse}\\ \text{Reflection}\\ \text{@ pt } (x', y')\end{pmatrix} = \frac{\begin{pmatrix}\text{Diffuse}\\ \text{Reflection}\\ \text{from } x\end{pmatrix} + \begin{pmatrix}\text{Diffuse}\\ \text{Reflection}\\ \text{from } y\end{pmatrix}}{2} \quad \ldots (6)$$

CMPE240
F2023

Project on Diffuse Reflection
Due Dec. 10 (Sun).

Nov. 27 (Monday).
Continuation on interpolation
for the Diffuse Reflection.
Ref: for the Diffuse Reflection.

2021F-101b-notes-cmpe240-2021-12-1 (1).pdf

From the Reference.

I_{diff} (Intensity) y

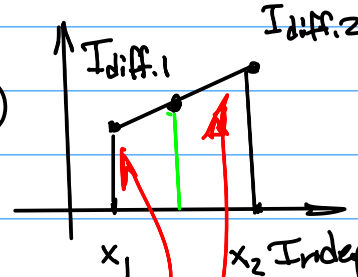
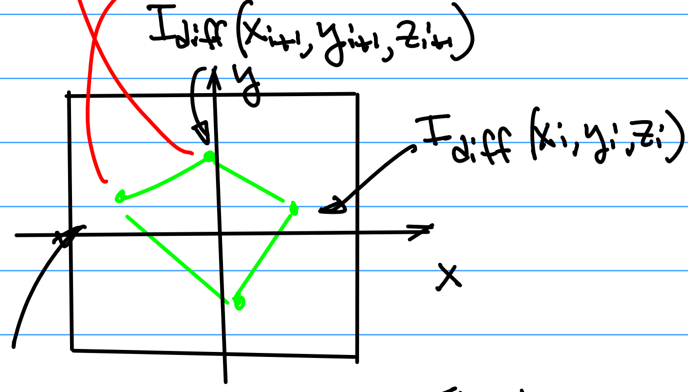


Fig. 1-a



$I_{diff}(x_{i+2}, y_{i+2}, z_{i+2})$

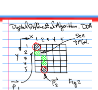
Fig. 1b.

$$\frac{x - x_2}{x_1 - x_2} = \frac{y - y_2}{y_1 - y_2} \quad \ldots (1)$$

$$y = \frac{y_1 - y_2}{x_1 - x_2} x - \frac{y_1 - y_2}{x_1 - x_2} x_2 + y_2 \quad \ldots (1b)$$

$y = ax + b$

slop offset



Hard Calculation on pp.61 (Ref)

From Eqn(1-b), Given (10, 0.78) and (20, 0.5)

$$\underline{\underline{I_{diff}}} = \frac{0.78 - 0.5}{20 - 10} x - \frac{0.78 - 0.5}{20 - 10} \cdot 10 + 0.5$$

$I_{diff,x}$ Notation

For $I_{diff,y}$, we have:

$$I_{diff,y} = \frac{0.78 - 0.5}{30 - 40} \cdot y - \frac{0.78 - 0.5}{30 - 40} \cdot 40 + 0.5$$

For $x = 15$, $y = 35$, substitute them into the Above equations to find the diffuse Reflection

$I_{diff,x}$, $I_{diff,y}$

So, the diffuse Reflection @ pt. (15, 35) is.

$$I_{diff} = \frac{1}{2}\left(I_{diff,x} + I_{diff,y}\right) \quad \ldots (2)$$

Therefore, Linear Interpolation with respect to X variable

$$I_d(15, 10) = \frac{80 + 90}{2} = 85$$

Now, to find the actual points on Each Boundary Line, we will Need DDA algorithm.
(Digital Differential Algorithm).

Example: Given 1. A finit Display device, 5×5 Below. 2. Starting pt $\vec{P_1}(1,1)$, and Ending pt $\vec{P_2}(2,5)$.

Digital Differential Algorithm. DDA

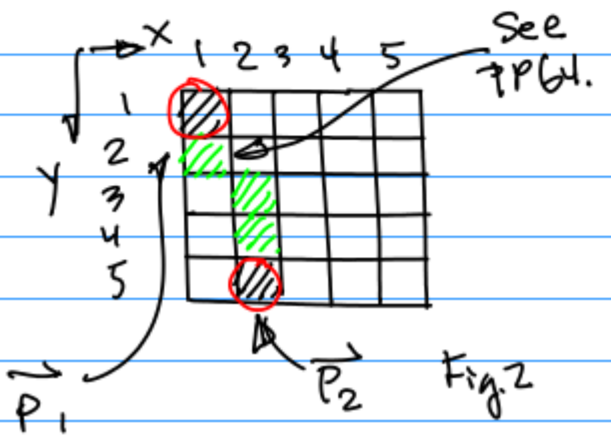


Fig.2

Find the Slop a.

$$a = \frac{y_{i+1} - y_i}{x_{i+1} - x_i} = \frac{5-1}{2-1} = 4$$

Note $|a| \geq 1$

To plot the line

$$y_{k+1} = a x_{k+1} + b \quad \ldots (3)$$

where $b = -\frac{y_k - y_{k+1}}{x_k - x_{k+1}} x_{k+1} + y_{k+1} = -4\times 2 + 5 = -3$

Verify it. Let $x=1$, find

$$y = ax + b = 4\cdot 1 - 3 = 1$$

To plot the Line.

$x_k = 1$,

$x_{k+1} = x_k + 1 = 1 + 1 = 2$

Hence

$$y_{k+1} = a\cdot x_{k+1} + b$$
$$= 4\cdot 2 - 3 = 5$$

Swap the x and y

$$\frac{1}{a} y_{k+1} = x_{k+1} + b/a$$

Hence $\left|\frac{1}{a}\right| \leq 1$

$$x_{k+1} = \frac{1}{a} y_{k+1} - \frac{b}{a} \quad \ldots (4)$$

This will fix the gap problem.

To verify $y_k = 1$

$$y_{k+1} = y_k + 1 = 2$$

$$x_{k+1} = \frac{1}{4} y_{k+1} + b = \frac{1}{4} \times 2 + 3/4 = 5/4$$
$$\simeq 1$$

Summary: Compute 4 Anchor Points Diffuse Reflection, then perspective projection for these 4 points. After that use BiLinear Interpolation + DDA Algorithm to find all Boundary Color.