Session Schedule

• Computer-Aided Design (CAD)
  • Introduction
  • Graphic primitives
  • Geometric modeling
  • Geometric modeling techniques
Computer-Aided Design (CAD)

- Graphic primitives:
  - A drawing is created by an assembly of points, lines, arcs, circles.
  - The drawing entities that a user may find in a typical CAD package include:
    - point
    - line
    - construction line, multi-line, polyline
    - circle
    - spline
    - arc
    - ellipse
    - polygon
    - rectangle

- DDA algorithm (Digital Differential Analyzer)
  - The digital differential analyzer generates lines from their differential equations.
  - The DDA works on the principle that X and Y are simultaneously incremented by small steps proportional to the first derivatives of X and Y.
  - In the real world of limited precision displays, addressable pixels only must be generated.
Computer-Aided Design (CAD)

* Graphic primitives:
  * Procedure DDA (X1, Y1, R : integer) ;

```c
As begin
For(int theta=0; theta<360; theta++)
{
  Plot(X1+R*cos(theta), Y1+R*sin(theta))
}
```

\[ x^2 + y^2 = r^2 \]
Computer-Aided Design (CAD)

* Graphic primitives:
  
  * Procedure DDA (XI, Y1, R : integer) ;
  * As begin
    * DTetha=1/R;
    * For(int tetha=0; tetha<2*π; theta+=Dtetha)
      {
        Plot(X1+R*cos(theta), Y1+R*sin(theta))
      }

  
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Computer-Aided Design (CAD)

- Graphic primitives:
  - Procedure DDA (X1, Y1, R : integer);
  - As begin:
    - Tetha=1/R;
    - X=R*Cos(Tetha); Y=R*Sin(Tetha);
    - For(int i=0; i<2*Pi*R; i+=(1/R))
      
      plot(truncate(X+X1±0.5), truncate(Y+Y1±0.5));
      Xtemp=X*Cos(Tetha)-Y*Sin(Tetha);
      Ytemp=X*Sin(Tetha)+Y*Cos(Tetha);
      X=Xtemp; Y=Ytemp;

Homework: AT:G:03:#

- Extend the simple program of group HW3 for plotting geometric objects. You should use your CIM data base structure to maintain the geometric data.
  - A simple interface can be applied to plot the geometric objects.

- You should provide your second module/procedure to plot a circle by getting the required center Cartesian location and radius s in a 2D space.

- The HW should be sent to Fvalilai@Sharif.edu till Sunday, 11th of Aban (Nov. 2nd, 2014)
- Email subject: “AT:G:03:#”
Computer-Aided Design (CAD)

- Graphic primitives:
  - Transformations
    - Scaling
    - Translation
    - Rotation

\[
R_x = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & \cos\phi & \sin\phi & 0 \\
0 & -\sin\phi & \cos\phi & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

\[
R_y = \begin{bmatrix}
\cos\phi & 0 & -\sin\phi & 0 \\
0 & 1 & 0 & 0 \\
\sin\phi & 0 & \cos\phi & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

\[
R_z = \begin{bmatrix}
\cos\theta & \sin\theta & 0 & 0 \\
-\sin\theta & \cos\theta & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

Computer-Aided Design (CAD)

- Geometric modeling:
  - Product development activity starts with the design of the product.
  - Manufacturing of machine parts and components is carried out with the help of drawings.
Computer-Aided Design (CAD)

* Geometric modeling:
  * The machine operator is provided with the drawing of the finished part and an operation sheet which gives step by step instructions to produce the part.

* Drawings are also required for
  * Process planning,
  * Tool design,
  * Production planning,
  * CNC programming,
  * Inspection,
  * Assembly,
  * Costing

Computer-Aided Design (CAD)

* Geometric modeling:
  * In addition to production drawings of components, the design department has to create
    * Layout drawings,
    * Assembly drawings,
    * and tool drawings (Jigs, fixtures, templates, special tools, inspection fixtures).

* In addition to component drawings, it is usually necessary to create hundreds of tool drawings and jig and fixture drawings for manufacture, assembly and inspection.
Computer-Aided Design (CAD)

- Geometric modeling:
  - Computer representation of the geometry of a component using software is called a geometric model.

- Geometric modeling is done in three principal ways:
  - Wire frame modeling
  - Surface modeling
  - Solid modeling

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**Computer-Aided Design (CAD)**

- **Geometric modeling**:
  - Wire frame modeling

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### 2-D Models vs. 3-D Wire Frame Models

<table>
<thead>
<tr>
<th>2-D Models</th>
<th>3-D Wire Frame Models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ends (vertices) of lines are represented by their X and Y coordinates.</td>
<td>Ends of lines are represented by their X, Y and Z coordinates.</td>
</tr>
<tr>
<td>Curved edges are represented by circles, ellipses, splines etc. Additional views and sectional views are necessary to represent a complex object with clarity.</td>
<td>Curved surfaces are represented by suitably spaced generators. Hidden line or hidden surface elimination is a must to interpret complex components correctly.</td>
</tr>
<tr>
<td>3-D image reconstruction is tedious.</td>
<td>2-D views as well as various pictorial views can be generated easily.</td>
</tr>
<tr>
<td>Uses only one global coordinate system</td>
<td>May require the use of several user coordinate systems to create features on different faces of the component.</td>
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</tbody>
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