## **Digital Representation BMEEPAGA205** > 2D drafting > 3D modeling

#### lecturer: László Strommer PhD



#### Drawing → Placing new elements into the drawing. -> The Drawing Unit can be chosen freely (Ma11 → The characteristic points of the drawing element can be specified either by the mouse or the keyboard or by combining the above. → Usually, several methods can be selected, e.g. for a circle. center madius / diameter, 2 diameter endpoints, 3 points. The saved elements are usually uniform, independent from the method of creation →Exceptions: e.g. "associative" hatching, array (in 3D the box and the extended rectangle are different).

#### Layers

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Layers make the structure of the drawing more transparent and more organized. → The name of the lavers can be freely changed (except 0), organized into a system (→templates) → All elements of the drawing are placed on figurative, three-dimensional layers →Newly drawn elements are placed on the Durrent lave → Newly utawit elements are paced on the correlat ages. Layer Status → Unlock/Lock: elements on a locked layer cannot be modified

→ On/Off: the content of a turned off layer is not displayed -> Than/Freeze: the content of a frozen layer is not generated, so it is invisible unorintable (the current layer cannot be frozen) zze in current / new viewport: like Freeze but only in given viewports → Print: the content of a frozen layer is not printed (even if it is visible on the screen)

#### PaperSpace The drawing file can contain a model and several layout tabs Jawyite can be deleted incerted covied renamed etc. → The following can be specified for layout: → printer type, page size, orientation, → plot stamp (e.g. file name, date), → printed lineweight. → The layout is not the same as the print preview: No adara Naro belginunt the content of the non-printed layers are visible → and it is possible to draw in it. → Each layout has a unique 2D PaperSpa Chick paper spece of Ref. derig an Dise: The specific like contain standard elements (e.g. captions, lines) and special ViewPort elements depicting the model

#### Blocks

The use of blocks makes it easier to handle frequently used elements (e.g. selecting each component of a complex shape when copying).\* → The drawing file will be smaller, as the block definition only needs to be saved once, and it is enough to store the unique properties (e.g. location) of the inserted instance. -> The blocks can be redefined making it easier to make global change



#### **Exporting / Properties**

Drawing elements can be copied between drawings - but the pasted elements don't always appear the same. -> Every element refers e.g. to its layer and linetype, some to text and/or dimension style, block definition → General rule for these properties: ightarrow if an element (layer, linetype, style) with the same name exists in the target file, it is used unchanged, ⇒if it doesn't exist, it is created automatically, as defined in the source file. If a DiningTable block and its dashed dimensions are pasted into a drawing (Ctrl+C/Ctrl+V). → if a block definition with the same name exists, that will be inserted instead. → if not, but a Chair block definition exists, then the new DiningTable block will use that, ⇒ if a Furniture layer exists all elements of the block with Bul aver rolor will inherit its rolor ightarrow if a Dashed linetype definition exists, the dimensions may appear differently from the original, -> if a Dim dimension style exists, the dimensions will be displayed according to that (e.g. with different size). → if not, but a Dim text style exists, the dimension text is displayed according to that (e.g. using different font

#### View · Visual Styles

→X-Ray

→ Sketchy

- ⇒ 2D Wreframe 2D projection is performed by the program, the video card displays 2D vectors (alias) -h Wireframe farter, but often lerr reliable dirolay (depends on video card) overwrite hidden edges with background color → Hidden
- → Conceptual warm-cold color transition instead of light-dark display materials, textures (transparency). → Realistic transparent surfaces (all edges visible) schematic display (e.g. line extension, edge vibration)











age Formats	
	WEBP
ressed format	→ all-in-one solution, more efficient compress
e size, low computing requirements	→ lossy and lossless, transparency, animation ICD
compression, but max, 256 colors	→ images with multiple resolutions and color
on (poor efficiency and quality)	TIFF
	→ flexible professional format.
compression → computing	→ several color modes, 1-64bit, more images
or or palette, +transparency (1-8 bit)	PSD / CPT / ACDC
	→ layers, masks (adjustment layers)
mpression → quality / loss of fidelity	RAW / DGN
rendered images	→ native format of digital cameras
-	→ images with greater color death (HDR)

→ truecol

→ lossy co → photos.

JPG



ixel / Vector	
puter displays a raster image — the drawing elements tored in vector and/or pixel format. armat: ing elements can be separated using layers.	
fication usually results in loss of information ing, random rotation — or sharpening).	1 Chait version-"1.8" encod 2 creg 3 width="256.8px" height
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depending on the hardware (e.e. transparency, shadows). Rendering can produce an even more realistic image. but not in real time, but over several minutes: → the quality (and time) can be controlled, → the resolution of the output file can be set, → lights materials background can be used. (however, these can also appear in a realistic visual style).

The level of realism of the visual styles can be adjusted

Curved sarfaces are approximated by a mesh wit Surfaces whose normal points in the opposite

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	Automatization Le	vels	
ß	⇒ A program module is a procedure written in a programming language (AutoLisp, VBA). ⇒ ActiveX enables you to manipulate AutoCAD e.g. from an Excel VBA.	Comparison on two         Comparison two         Comparison two <th< th=""><th></th></th<>	
	<ul> <li>→ A macro (Action Macro, ACIM) is a recorded commad sequence.</li> <li>→ B utions and records commad sequence.</li> <li>→ A script is a list of program instructions.</li> <li>→ Comma aliances can be used (PGP).</li> <li></li></ul> <li></li>		

# CAD Basics 2D drafting

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## **Command Entry**



#### **Command Prompt**

Every command appears in the command bar **Togglable Pointer Input** 

#### **Ribbon Bar / Tool Icon**

**Command icons** 

Show the pulldown menu (MenuBar 1)

2

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## Coordinates · 2D

Cartesian coordinates: x, y
→ the x and y projections of the distance from the current origin or the last point

#### Polar coordinates :

d<a

→ distance from the current origin or the last point, and the angle relative to the x-axis Absolute coordinates :

 $\rightarrow$  (DynPiCoords = 0)

ightarrow coordinates measured from the current origin

Relative coordinates :a $\rightarrow$  coordinates measured from the last point



#

- ightarrow use point as decimal symbol, and comma as list separator,
- ightarrow variable names are always English, and
- $\rightarrow$  all English commands can be used after an underscore (e.g. \_Line).

## Drawing Aids · 2D



- **Coord**  $\rightarrow$  coordinates (abs. cart. / rel. polar / geographic) Ctrl+I  $\cdot$  Coords 0-1-3
- Grid  $\rightarrow$  displaying points / lines at a given distance as visual help F7 · GridMode 0-1
- Snap  $\rightarrow$  restricting cursor movement to grid points at a given distance F9  $\cdot$  SnapMode 0-1
  - $\rightarrow$  dynamic (moving) entry field for commands or data F12  $\cdot$  DynMode 0-3
- **Ortho**  $\rightarrow$  restricting vectors to perpendicular directions F8  $\cdot$  *OrthoMode* 0-1
  - $\rightarrow$  follows the angle of the grid  $\rightarrow$  overrules the Snap mode in the given direction
- Polar  $\rightarrow$  restricting vectors to given angles F10  $\cdot$  PolarMode 0-15

Dyn

- **OTrack**  $\rightarrow$  showing snapping reference lines F11 · AutoSnap 0-63
- OSnap  $\rightarrow$  showing characteristic points of drawing elements F3  $\cdot$  OSMode 0-1151-16k  $\rightarrow$  "running" object snap overrules the Snap and Ortho modes

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## Drawing

- $\rightarrow$  Placing new elements into the drawing.
- $\rightarrow$  The Drawing Unit can be chosen freely (M=1:1).
- $\rightarrow$  The characteristic points of the drawing elements can be specified either by the mouse or the keyboard, or by combining the above.
- $\rightarrow$  Usually, several methods can be selected, e.g. for a circle: center +radius / diameter, 2 diameter endpoints, 3 points.
- $\rightarrow$  The saved elements are usually uniform, independent from the method of creation.
  - $\rightarrow$  Exceptions: e. g. "associative" hatching, array (in 3D the box and the extended rectangle are different).

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# Modifying, Selection

To use modifying commands, the elements must be selected first — either before or after starting the command. These commands can also change the element type (e.g. Circle +Trim  $\rightarrow$  Arc).

- **Selection methods**
- ightarrow Auto: clicking in an empty area specifies the first point of the diagonal of a selection box
  - $\rightarrow$  second point to the right  $\rightarrow$  elements within the frame are selected (Window),
  - $\rightarrow$  to the left  $\rightarrow$  elements crossing the boundary are selected also (Crossing)
- $\rightarrow$  WP/CP: Window/Crossing selection modes with a polygonal boundary
- $\rightarrow$  Previous: re-selecting the previous item list
- $\rightarrow$  Last: selecting the last created element
- $\rightarrow$  All: selection of all available drawing elements
- $\rightarrow$  Undo: undoing the last selection
- ightarrow By pressing Shift, elements can be removed from the selection.
- $\rightarrow$  The selection can be reversed with the Remove / Add) options.



## **Element Types**

The saved elements are usually uniform, independent from the method of creation.

The same item can be produced by multiple commands...

- $\rightarrow$  LWPOLYLINE element can be created for example...
  - $\rightarrow$  by drawing a PLine a Polygon or a Rectangle,
  - ightarrow by connecting existing line and arc elements a with Join or Pedit,
  - $\rightarrow$  by drawing the outline of existing elements with Boundary,
  - $\rightarrow$  by modifying existing polylines with Stretch, Offset.
- $\rightarrow$  SPLINE element can be created for example...
  - → by drawing a polyline with PLine, then modifying it by Pedit / Spline, then converting it by the Object option of the Spline command.



## Layers

Layers make the structure of the drawing more transparent and more organized.

- $\rightarrow$  The name of the layers can be freely changed (except 0), organized into a system ( $\rightarrow$ templates).
- $\rightarrow$  All elements of the drawing are placed on figurative, three-dimensional layers.
  - $\rightarrow$  Newly drawn elements are placed on the Current layer.
  - $\rightarrow$  Copies of existing elements are typically placed on the original layer.

#### Layer Status

- $\rightarrow$  Unlock/Lock: elements on a locked layer cannot be modified
- $\rightarrow$  On/Off: the content of a turned off layer is not displayed
- → Thaw/Freeze: the content of a frozen layer is not generated, so it is invisible, unprintable, (the current layer cannot be frozen)
- → Freeze in current / new viewport: like Freeze but only in given viewports
- $\rightarrow$  Print: the content of a frozen layer is not printed (even if it is visible on the screen)



## **Properties**

The general properties are the same for all elements.

- ightarrow For color, linetype and thickness :
  - $\rightarrow$  a specific value can be set (e.g. white, dashed, 0.3 mm),
  - $\rightarrow$  the properties of the block containing it can be inherited (later),
  - $\rightarrow$  the properties of the element's layer can be inherited.
- $\rightarrow$  Layers are invisible they set the default properties of their elements.
- → The line weight cannot be accurately judged on the screen, so the color mostly helps to identify the layer of the elements (especially in 2D).

#### Colors

→ seven basic colors by names for the (white → inverse), the standard colors of the AutoCAD Color Index by numbers (1-255), additional colors by RGB value or Pantone name.



# CAD PaperSpace Blocks

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## PaperSpace

The drawing file can contain a model and several layout tabs.

Layouts can be deleted, inserted, copied, renamed, etc.

- $\rightarrow$  The following can be specified for layout:
  - $\rightarrow$  printer type, page size, orientation,
  - $\rightarrow$  plot stamp (e. g. file name, date),
  - $\rightarrow$  printed lineweight.
- $\rightarrow$  The layout is not the same as the print preview:
  - ightarrow the content of the non-printed layers are visible,
  - ightarrow and it is possible to draw in it.
- → Each layout has a unique 2D PaperSpace contain standard elements (e.g. captions, lines) and special ViewPort elements depicting the modell.



Model

Lavout1

Layout2 / +

## Viewport

 $\rightarrow$  A ViewPort always shows the current state of the model.

- → However, layers can be frozen per ViewPort, so their content is not necessarily the same.
- → By double-clicking inside a ViewPort, we can move into ModelSpace, where we can modify the model itself and the change will be visible in all viewports.
- → After entering ModelSpace, we can maximize the ViewPort to full size, or we can switch between the ViewPorts (even during a command).
- ightarrow The scale of the view can be adjusted:
  - → if the model space unit is meter, the paper space unit is millimeter, the scale of a 1:50 drawing is 20xp (50 × 20 mm = 1000 mm = 1 m),
  - $\rightarrow$  the list of standard scales can be modified (ScaleListEdit),
  - $\rightarrow$  the scale and view of the viewport can be locked (Display Locked).

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## Blocks

The use of blocks makes it easier to handle frequently used elements (e.g. selecting each component of a complex shape when copying).\*

→ The drawing file will be smaller, as the block definition only needs to be saved once, and it is enough to store the unique properties (e.g. location) of the inserted instance.

 $\rightarrow$  The blocks can be redefined, making it easier to make global changes.

\* If the only goal is to keep the elements together, it is enough to use the Group command. Group selection can be switched on and off (*PickStyle*, Ctrl+Shift+A).



## **Block Definition**

A block...

- $\rightarrow$  can be defined with the Block command
- $\rightarrow$  must have a unique name in the drawing file (Purge),
- ightarrow can contain drawing elements and other blocks (except a block containing itself),
- ightarrow should have an insertion point that can be easily specified when inserted
- ightarrow should have elements with 0-degree rotation angle to facilitate insertion.
- A defined block can be inserted into the drawing with the Insert command (or by copying an existing instance). By specifying an existing name, the block can be redefined:
- ightarrow every instance of the block takes over the new definition,
- $\rightarrow$  the base point and rotation angle should not be changed (RefEdit).

#### See also: <u>Layers</u> · <u>Properties</u>

## **Block Properties**

Color (linetype, lineweight...) and layer of block elements: Given **Given Color** – the element keeps its original color  $\rightarrow$  all such elements have the same color. **ByBlock Color** – the element inherits the color of its block  $\rightarrow$  elements of different blocks can have different color. **ByLayer Color** – the element inherits the color of its layer. **General Layer** – the element remains on its original layer  $\rightarrow$  the block definition refers to the layer (hence the layer cannot be purged from the drawing),  $\rightarrow$  the element disappears when its original layer is turned off. **O Layer** – the element is placed on the layer of its block **Block**  $\rightarrow$  each block instance can be on a different layer  $\rightarrow$  the element disappears when the *layer of its block* is turned off.

Color > General **Bylayer** Color > Layer > 0 Layer > Color >

## **Block Behaviour**

An element's color... if the original had and it was on layer 0: it was on another layer:

ANY Color	ByBlock color	ByLayer color	
А	В	insertion layer	color,
A (no!)	B (NO!)	original layer	color.

→ Elements with different properties can be combined into a block with complex behavior (e.g. in a chair block the textile can have ByBlock, the legs ByLayer, the castor grey color).

 $\rightarrow$  The properties of the elements included in the block can only be changed by redefining the block.

**)** /

## **Blocks / Layers**

Block elements on layer 0 – ByBlock properties:
→ the block behaves like a normal drawing element (it can be moved from one layer to another, and it can have varying colors or linetype).
Block elements on a separate layers:

 $\rightarrow$  the drawing can be made more structured but requires more care. Block elements on a multiple layers:

→ one instance can have several colors (lineweights, linetypes),
 → the block can be displayed in different representations
 (e.g. the 2D symbol in one viewport, the 3D model in the other)

Block elements on layer 0 (n×8):

1\_DOOR 1\_GLAZ 1\_EQPM 1\_FURN 1\_WALL 1\_FILL 1\_FILL 1\_FLOR 1\_DIMS 2\_DOOR

...

...

Elements on separate layers (4+n×4): -DOOR -GLAZ -EQPM -FURN 1\_WALL 1\_FILL 1\_FILL 1\_FLOR 1\_DIMS 2 WALL

## Dynamic Blocks / 5D Blocks

Multiple contents in a single block definition:

- $\rightarrow$  can be used to display different versions (e.g. different types of trees, cars...),
- $\rightarrow$  can be used to manage size variations (e.g. different window sizes),
- ightarrow can be used to display different states (e.g. door opening angle),

ightarrow can contain the 2D symbol and the 3D model of an object.









## **Blocks With Attributes**

Blocks can contain numerical and/or textual data in addition to or instead of drawing information (e.g. the name, covering and area of the room).

Attribute definitions can be included in the block (creation: AttDef):

 $\rightarrow$  when inserted, they are either use default values, or request data,

 $\rightarrow$  the information stored this way can be collected and saved into a file.

#### **Text Style**

- $\rightarrow$  New styles (font, style, size) can be created (Style)
  - existing styles can be used (DText).

#### **Dimension Style**

 $\rightarrow$  The style of dimensions can be defined and modified (DimStyle).

Kitchen ceramic 6 m<sup>2</sup>

## **Exporting / Properties**

Drawing elements can be copied between drawings — but the pasted elements don't always appear the same.

- → Every element refers e.g. to its layer and linetype, some to text and/or dimension style, block definition.
- $\rightarrow$  General rule for these properties:
  - → if an element (layer, linetype, style) with the same name exists in the target file, it is used unchanged,
  - $\rightarrow$  if it doesn't exist, it is created automatically, as defined in the source file.
- If a DiningTable block and its dashed dimensions are pasted into a drawing (Ctrl+C / Ctrl+V)...
- ightarrow if a block definition with the same name exists, that will be inserted instead,
- → if not, but a Chair block definition exists, then the new DiningTable block will use that,
- → if a Furniture layer exists, all elements of the block with ByLayer color will inherit its color,
- $\rightarrow$  if a Dashed linetype definition exists, the dimensions may appear differently from the original,
- → if a Dim dimension style exists, the dimensions will be displayed according to that (e.g. with different size),
- $\rightarrow$  if not, but a Dim text style exists, the dimension text is displayed according to that (e.g. using different font).

# CAD > 3D modelling

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## View · Visual Styles

- $\rightarrow$  2D Wireframe
- $\rightarrow$  Wireframe
- $\rightarrow$  Hidden
- $\rightarrow$  Conceptual
- $\rightarrow$  Realistic
- →X-Ray
- $\rightarrow$  Sketchy

2D projection is performed by the program, the video card displays 2D vectors (alias) faster, but often less reliable display (depends on video card) overwrite hidden edges with background color warm-cold color transition instead of light-dark

- display materials, textures (transparency).
- transparent surfaces (all edges visible)
  - schematic display (e.g. line extension, edge vibration)

[-][Custom View][2D Wire	eframe	
	Custom Visual Styles >	MonoGooch Special
	✓ 2D Wireframe Conceptual	Realistic with jittered edges
	Realistic Shaded	
	Shaded with edges Shades of Gray	( )
	Sketchy Wireframe	
	X-ray	
	Visual Styles Manager	

## **View · Projection Types**

Any viewing angle can be used — either in parallel or perspective projection mode.

 $\rightarrow$  Using a general viewing angle helps to avoid overlapping lines.

 $\rightarrow$  Free movement and rotation using the mouse: 3dOrbit.

 $\rightarrow$  2D angle in the base *xy*-plane + 3D angle from the *xy*-plane: ddVPpoint.  $\rightarrow$ 

→ Exact 3D position: Camera:

viewpoint +target point +properties (e.g. viewing angle / zoom)

→ Alternative that also works on Mac: Dview: Points +Distance +Zoom.

Viewpoint Presets	×
Set Viewing Angles	
Absolute to <u>W</u> CS	◯ Relative to <u>U</u> CS
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Set to Pla	an <u>V</u> iew
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## **View · Viewports**

Viewports can also be used in 2D (*e.g. floor plan variations, multiple nodes, detailed drawing...*). Their use in 3D is almost inevitable (*e.g. for views of the same model*)...

 $\rightarrow$  alignment of views is important (Zoom Center),

 $\rightarrow$  the dimensions shouldn't be seen in any other viewports than where they belongs.

Model space dimensions — the size of the dimension depends on the printing scale (*DimScale*) ...

 $\rightarrow$  separate layer for each view (frozen in the other viewport),

- $\rightarrow$  it is worth using the frozen in new viewports layer setting,
- ightarrow in existing viewports, the display must be disabled one by one.

Paper space dimensions — it is enough to use one size (*DimScale*), but the scale of the view becomes important

- $\rightarrow$  scale the paper space distances (*DimLFac*) e.g. meter in 1:200  $\rightarrow$  1 m = 5 mm  $\rightarrow$  *DimLFac* = 20
- $\rightarrow$  connect dimensions to drawing elements e.g. showing meters in cm  $\rightarrow$  DimLFac = 100 enable associative dimensioning  $\rightarrow$  DimAssoc = 2 (Options)

## **3D Coordinate System**

#### Cartesian X, y, Z

→ x, y, z distances from the starting point
 (from the current origin or from the last point)

#### Cylindrical d<a,z

- $\rightarrow$  the projection of the distance in the *xy* plane,
- $\rightarrow$  the angle from the *x*-axis,
- $\rightarrow$  and the *z* coordinate.

### **Spherical** d<a<b

- $\rightarrow$  distance from the starting point,
- $\rightarrow$  the angle from the *x*-axis,
- $\rightarrow$  the angle from the *xy*-plane.

Accuracy check: ID and Dist



## **3D Points**

3D point entry can often be omitted ...

- $\rightarrow$  by selecting a point of an existing element using OSnap,
- $\rightarrow$  by using filters (e.g. . x, . xy), combining the coordinates of several elements (and/or coordinate entry),
- ightarrow by aligning the UCS so that 2D (rectangular or polar) coordinates could be used.

If there are different coordinate systems in the viewports, the coordinate system of the active window will be valid during its execution.

## UCS

Every drawing has a World Coordinate System, WCS. Any number of User Coordinate Systems UCS, can be defined.

A new UCS can be defined in many ways:

 $\rightarrow$  can be generated by rotating the current UCS around the x, y, or z axis,

 $\rightarrow$  a new origin, z-axis can be specified, or it can be defined with t

Name

 $\rightarrow$  can be aligned with the viewing direction or to an object.

The active UCS can be saved (UCSMAN). ►

The value of the UCSVP variable:

- $1 \rightarrow$  every viewport can have its own UCS,
- $0 \rightarrow$  the UCS of the current viewport applies to all.



n three points,	Les Contraction of the second	×
UCS umed UCSs Orthographic UCSs Settings UCS Icon settings	Named UCSs Orthographic UCSs Settings Current UCS: Unnamed Vorld Set Current Previous 122 Delete Details	
Save UCS with viewport	OK Cancel Help Cancel Help	

## **Coordinate System · Elements**

The objects behave differently in 3D.

#### 2D Objects

- $\rightarrow$  e.g. PLine, Arc, Circle, Ellipse
- $\rightarrow$  their plane is always parallel to the *xy* plane of the current UCS
- $\rightarrow$  their height is determined by their first point, so the *z*-coordinates of the other points can be omitted.
- 2D-3D Objects
- $\rightarrow$  e.g. Line, 3dFace
- ightarrow the height of their points are arbitrary.

# **Coordinate System · Editing**

The modifying commands behave differently in 3D.

2D Commands

- $\rightarrow$  e.g. ROtate, MIrror, TRim, EXtend
- → their working plane is always parallel to the xy plane of the current UCS,
   i.e. the rotation axis is parallel to the z-axis, so it is enough to specify one of its points.
- **3D Commands**
- $\rightarrow$  e.g. Mirror3d, Rotate3d
- → they doesn't have a fixed working plane, which can be good (no need to change the UCS) but it can be unnecessary, because they require extra data (time / errors).

**Dimension-independent Commands** 

- $\rightarrow$  e.g. Copy, Move, STretch
- $\rightarrow$  by entering two coordinates they work in 2D, by entering the third coordinate they become 3D.







## Modell Types

2,5D model · thickness
3D surface model
3D solid model
3D primitives or 2D + Extrude / Revolve
+Boole operations or e.g. Slice





## **3D Workspace**

By changing the Workspace ►	Drafting & Annotation
the ribbon menus and palettes can be modified.	3D Basics
	✓ 3D Modeling
→ Personalized settings can be saved.	Save Current As Workspace Settings Customize
► Type a command	Display Workspace Label
0.00, 0.00, 0.00 MODEL # ::: ▼ 🔐 + 🖕 🖓 ▼ ∠ 🛄 ▼ 📰 🔚 🗊 ▼ 🔩 🗍 ▼	- 🌣 - 🗉 🗔 - ⊵ 🐌 🖓 鍋

× 7

By default, the 3D drawing aids are not visible in the status line, it is advisable to turn them on in order to see (and toggle) their status. ►



✓ Coordinates

## **3D Drawing Aids**

Type a command

It is important to turn on some 3D drawing aids — and turn off others. Dynamic UCS  $\rightarrow$  automatic adjustment of the xy plane of the coordinate system to a 3D reference plane, e.g. to a given face of a solid  $F6 \cdot UCSdetect$  0-1 3D Object Snap  $\rightarrow$  Finding characteristic points of 3D objects (3D drawing elements and scanned point clouds).  $F4 \cdot 3DOSMode$  10 **Ortho**  $\rightarrow$  restriction of vectors to axial directions F8  $\cdot$  OrthoMode Show / hide lineweights (real width only in the layout) · *LwDisplay* ON Display the transparency of elements (on / off) · TransparencyDisplay ON Select overlapping elements from a pop-up list Ctrl+W · SelectionCycling OFF Selected elements can be temporarily hidden or isolated: HideObjects / IsolateObjects / UnisolateObjects

3D Object Snap On (F4)	Point Cloud
Object Snap modes	Point Cloud
Vertex	382 Node
Midpoint on edge	∧intersection
Center of face	U DEdge
🖾 🗌 Knot	Y Comer
⊢ □ Perpendicular	X Nearest to plane
Nearest to face	Perpendicular to plane
	Perpendicular to edge
	Centerline
0	Select All Clear Al
Because 3D object snaps of	an slow performance, it is recommended that
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# CAD Basics of Pixel Graphics

Digital Representation BMEEPAGA205 László Strommer PhD.



## **Pixel / Vector**

The computer displays a raster image — the drawing elements can be stored in vector and/or pixel format.

#### **Pixel format**

- ightarrow Drawing elements can be separated using layers.
- → Modification usually results in loss of information (resizing, random rotation... – or sharpening).

#### Vector format

- → Drawing elements are geometric objects (e.g. circle, polygon, spline).
- → Geometric transformations do not result in quality loss.
   Mixed format
- → Pixel gradients, backgrounds, patterns, etc.,
   but e.g. vector texts, shapes.



## Pixel

The images stored and displayed by the computer consist of discrete picture elements — pixels. **Pixel** 

- → Brightness and color information for a given coordinate of the image.
- → It is often approximated by a rectangle, but it has no defined shape.
- $\rightarrow$  Pixel color  $\rightarrow$  typically by mixing primary colors.  $\blacktriangleright$



## Resolution

Resolution can characterize the pixel number or pixel density.

### Image resolution / dimension

→ The number of pixels, as a number (x×y, e.g. 800×600), with a name (e.g. SVGA), or approximately (e.g. 16MP camera).

### **Pixel density**

- ightarrow The distance between the pixels.
- → If it is the same in the x and y directions, the number of pixels determines the aspect ratio.
- → Typical resolution (dot/inch): monitor 72–96 dpi / printer 300-1200 dpi.



L

## **Color Depth**

Color depth (bits/pixel) is the sampling accuracy of colors. Typical color depth values:

- $\rightarrow$  1 bit  $\rightarrow$  2<sup>1</sup> = 2 colors (monochrome)
- $\rightarrow$  2 bits  $\rightarrow$  2<sup>2</sup> = 4 colors
- $\rightarrow$  4 bits  $\rightarrow$  2<sup>4</sup> = 16 colors or shades (two pixels / byte)
- $\rightarrow$  8 bits  $\rightarrow$  2<sup>8</sup> = 256 colors or shades (e.g. greyscale)
- $\rightarrow$  24 bits  $\rightarrow$  (2<sup>8</sup>)<sup>3</sup> = 16.7 million colors (256 shades / RGB)
- $\rightarrow$  32 bits  $\rightarrow$  16.7 million colors
  - & 256 steps of transparency (alpha channel)

#### HDR · High-Definition Range

- $\rightarrow$  30 bits  $\rightarrow$  (2<sup>10</sup>)<sup>3</sup> = 1 billion colors (1024 shades / RGB)
- $\rightarrow$  36 bits  $\rightarrow$  (2<sup>12</sup>)<sup>3</sup> = 68.7 billion colors (4096 shades / RGB)...



## Colors

Light visible to the human eye is the wavelength range of ~380 to 780 nm in the electromagnetic spectrum.



## Spectrum

The spectral power distribution function of the Sun's radiation energy shows the amount of energy for uniform wavelength intervals (with atmospheric absorption and without it).

The  $\Phi$  light falling on a material is either transmitted ( $\tau$ ), absorbed ( $\alpha$ ), or reflected ( $\rho$ ).  $\tau(\lambda) + \alpha(\lambda) + \rho(\lambda) = 1$ 

The source of the color stimulus can be a light source (light-color), or a light reflected from a surface (surface-color).

## Spectrum of Solar Radiation (Earth)



https://en.wikipedia.org/wiki/File:Solar\_spectrum\_en.svg

## **Color Sense**

The visual receptors of the human eye:

- $\rightarrow$  light-sensitive rods  $\rightarrow$  "night vision"
- ightarrow three types of color-sensitive cones
  - $\rightarrow$  for long (L), medium (M), short (S) wavelengths
  - $\rightarrow$  can distinguish 100-120 levels of brightness.

#### **Brightness and Color Constancy**

→ regardless of the changing light conditions, the sheet of paper is perceived as equally bright and the taxi is perceived yellow.

#### Metamerism

→ spectrally different colors can result in the same color perception, if the stimuli for the three receptors are identical.

Characteristics of the human color perception.

#### Lightness

 $\rightarrow$  the relative intensity of a colored light.

#### Saturation

ightarrow how much white and gray color the light contains.

#### Hue / characteristic wavelength

- → the wavelength of the monochromatic light that appears to have the same color. Helmholtz
   Light characterized by a given spectral distribution
- → appears red (green, blue) if it mostly contains that given range of the spectrum,
- → appears white, gray, or black if it stimulates the three receptors to the same extent.

## **CIE Tristimulus Values**

The CIE (International Commission on Lighting) color spaces were the first quantitative links between distributions of wavelengths in the visible spectrum, and the perceived colors.

- → Selected red, green, blue basic colors:  $\lambda$ (R) =700 nm,  $\lambda$ (G) =546.1nm,  $\lambda$ (B) =435.8 nm.
- → Experimentally established primary color units, whose sum appears to be a white light of equal energy:
   R = 0.17697 lm | G = 0.81240 lm | B = 0.01063 lm.
- → They tried to determine the ratio of the primary colors that results in the same color sensation as monochromatic light of a given wavelength — but one of the primary colors always turned up negative (had to be added to the target).



https://en.wikipedia.org/wiki/CIE\_1931\_color\_space https://en.wikipedia.org/wiki/File:CIE1931\_RGBCMF.svg

## **CIE xy Chromaticity Diagram**

1.0

By placing the chosen primary colors on the corners of a triangle
→ colors that can be mixed from them are located inside,
→ colors with negative values are located outside.
It was more expedient to use virtual primary colors X, Y, Z,

- $\rightarrow$  resulting in three positive values for each real color,
- → for this, the XYZ triangle must enclose the spectral locus (the pure hues of a single wavelength) and the purple line. 2.0 2.
- ightarrow but the brightness factor Y must be specified.

Obviously, there are other color schemes, and the CIE system has also been refined several times (for example, to make the color space more uniform).



## **RGB Model**

Additive color mixing takes place in the human eye:

- ightarrow by projecting colored lights onto a reflective surface,
- → by projecting different colors into the eye in rapid succession (with a frequency greater than 50 Hz)
- → with densely placed small dots of the colors to be mixed (so that the eye cannot separate them).

#### RGB / Displays

- $\rightarrow$  Additive mixing of red, green and blue primary colors.
- ightarrow The value of the basic colors can vary between 0-1.







## CMY / CMYK Model

In the case of subtractive color mixing, the color is created jointly by the light source, the colored surfaces that reflect the light, and the color filters placed in the path of the light.

 $\varphi(\lambda) = \Phi(\lambda) \cdot \rho(\lambda) \cdot \tau(\lambda)$ 

The color of the light is decided by the dominant spectral range in the distribution of the relative power of the light.

#### CMY-CMYK / Printing

- $\rightarrow$  Subtractive mixing of cyan, magenta, yellow.
- ightarrow The reflected light decides the color:
  - $\rightarrow$  the colors of the points are given,
  - $\rightarrow$  more saturated color  $\rightarrow$  bigger point size,
  - $\rightarrow$  to avoid overlapping  $\rightarrow$  rotated grids.
- ightarrow Black ink yields much better blacks.



## YCbCr Model

A Y'CbCr color space can be determined by coordinate transformation of the primary colors and white point of an RGB color space.

- → Y' the luma component, which can be stored and transmitted in high resolution,
- → Cb and Cr are the blue-difference and reddifference color components, which can have reduced bandwidth for the sake of efficiency.

#### Chroma subsampling

The human visual system is less sensitive to color differences than to luminance,

→ when encoding images, a lower resolution can be used for color than for luma information.

https://en.wikipedia.org/wiki/YCbCr https://en.wikipedia.org/wiki/Chroma\_subsampling





## Gamut

The CIE xy chromacity diagram represents all the chromaticities visible to the average person. The colored region is called the *gamut* of human vision.

- → Gamut is the set of colors that can be accurately represented by a device or a a color space.
- → The gamut of the printer (CMYK) and the monitor (RGB) do not match — there are colors that can be reproduced by one, but not by the other (vica versa).
- → Devices obviously have to use real primary colors, so their gamut is always incomplete.
- → A color system, can contain fictitious colors that humans cannot see (in order to increase the gamut).

If the M cone alone could be stimulated, the brain would see a color that is greener than what is physically possible. https://en.wikipedia.org/wiki/Gamut



https://en.wikipedia.org/wiki/Impossible\_color

https://en.wikipedia.org/wiki/File:CIE1931xy\_gamut\_comparison.svg

## **Image Formats**

#### BMP

- ightarrow uncompressed format
- ightarrow large file size, low computing requirements

#### GIF

- $\rightarrow$  lossless compression, but max. 256 colors
- → animation (poor efficiency and quality)PNG
- $\rightarrow$  lossless compression  $\rightarrow$  computing
- → truecolor or palette, +transparency (1-8 bit)
   JPG
- $\rightarrow$  lossy compression  $\rightarrow$  quality / loss of fidelity
- ightarrow photos, rendered images

#### WEBP

- $\rightarrow$  all-in-one solution, more efficient compression
- ightarrow lossy and lossless, transparency, animation

#### ICO

- → images with multiple resolutions and color TIFF
- ightarrow flexible professional format
- $\rightarrow$  several color modes, 1-64bit, more images

#### PSD / CPT / ACDC ...

 $\rightarrow$  layers, masks (adjustment layers)

#### RAW / DGN

- ightarrow native format of digital cameras
- $\rightarrow$  images with greater color depth (HDR)

## Specialities

#### Multiple images in one file

- → thumbnail (e.g. JPG)
- $\rightarrow$  alfa channel (e.g. PNG)
- $\rightarrow$  combinations of images, masks (e.g. PSD)
- → multi-page (e.g. TIFF)
- ightarrow multi-image (e.g. ICL)
- $\rightarrow$  animations (e.g. GIF)

#### Palette

- $\rightarrow$  defining palette colors
  - (e.g. 0=FFFFF 1=000000 2=990033 3=0066CC)
- $\rightarrow$  image color by the palette (2 bits instead of 3×8)
- $\rightarrow$  compression

#### Metadata / EXIF7

- → Machine > Make, Model, Software
- → Photo > Aperture, Shutter, ISO, Focal Length
- → Image > Color Profile, White Balance
- → Color > Color Space (sRGB), Mode (YCbCr)
- → GPS > Latitude, Longitude, Timestamp
- → Thumbnail > Latitude, Longitude, Timestamp

#### Metadata / IPTC7

- $\rightarrow$  Location > Country, City, Location
- $\rightarrow$  Info > Keywords, Credit, Contact

#### Metadata / XMP sidecar 7

→ if the original is not suitable for storing metadata (Extensible Metadata Platform)

# CAD > Rendering > Data Exchange

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## Rendering

The level of realism of the visual styles can be adjusted depending on the hardware (e.g. transparency, shadows).

Rendering can produce an even more realistic image, but not in real time, but over several minutes:

- $\rightarrow$  the quality (and time) can be controlled,
- ightarrow the resolution of the output file can be set,
- → lights, materials, background can be used
   (however, these can also appear in a realistic visual style).

Curved surfaces are approximated by a mesh with controllable density (ViewRes × FacetRes). Surfaces whose normal points in the opposite direction can be excluded from the calculation.



## Views

The aspect ratio of the paper space viewport decides the dimensions  $\rightarrow$  using standard ratios is recommended (4:3, 16:9, etc.).. The view can be specified and adjusted in several ways:  $\rightarrow$  3dOrbit:

projection: Parallel / Perspective

 $\rightarrow$  ddVPpoint:

directions in the base plane + from the base plane

 $\rightarrow$  Camera:

camera +target +properties (e.g. zoom)

→ DView (an alternative that also works on Macs): Points (target +camera) +Distance +Zoom



It is recommended to save the view with the View command (this is automatic for the camera).

## Visual Styles

**Visual Styles** 

 $\rightarrow$  2D Wireframe

- $\rightarrow$  Wireframe
- $\rightarrow$  Hidden overwriting hidden edges with background color
- → Conceptual warm-cold transition instead of light-dark
- $\rightarrow$  Realistic displaying materials, textures (transparency)
- → X-Ray transparent surfaces (all edges are visible)
- $\rightarrow$  Sketchy e.g. line extension, edge vibration

Visual styles can be customized by changing their edge and surface settings. ►

the projection is done by the video card

MonoGooch Spec 0. Face Settings Face style Gooch Lighting guality Smooth Color Monochrome 255,255,255 Monochrome... Opacity Material display Off  $\bigcirc$ Lighting **Environment Settings Edge Settings** Isolines Show Number of lin... 0 White Color Always on top No **Occluded Edges** Intersection Edges

VISUAL STYLES MANAGER

Available Visual Styles in Drawing

Styles can be transferred between drawings using the Tool Palette, first by exporting them to the active sheet of the palette, then adding them to the other drawing from there.

the projection on the plane is performed by the program (antialiasing)

## **Traditional Lights**

Several types of lights can be used...

 $\rightarrow$  Ambient

 $\rightarrow$  Distant

 $\rightarrow$  Point

 $\rightarrow$  Spot

instead of calculating light scattered in the atmosphere and from surfaces,
too much → blurred image | not enough → over-contrast lunar landscape
the power of a light source characterized only by its direction (and intensity)
its power does not decrease with the distance between objects (e.g. sun)
light source radiating equally in all directions (e.g. lamp)
attenuation with distance can be applied
light source characterized by its position and direction (e.g. spotlight)

the light cones of full and dimmed lighting can be specified

## **Photometric Lights**

In newer versions, photometric lights can be used — it is important to specify the drawing unit (\_Units)...

- $\rightarrow$  physically more realistic, predefined lights from the Tool Palette,
- ightarrow the sun and the sky can be used
  - ightarrow as a changing background (according to the date and time),
  - ightarrow to illuminate the model with ambient light,
- $\rightarrow$  to display realistic sun angles (<u>Units</u> / north direction, geolocation). the default lighting should be turned off.







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ок с	ancel	Direction	Help

## Materials

The display can be made more realistic by using materials.
The materials can be loaded from the library (Material Browser):
→ the definitions are included in the file (the textures are not!),
→ the material characteristics can be assigned
→ to the layers (\_MaterialAttach),

→ to the elements (by dropping the material on them or through their Properties panel),

 $\rightarrow$  or to the individual surfaces of the elements (Ctrl+drop). The scale of the pattern can be adjusted

ightarrow bump map and/or transparency map can be used.

The scale of the texture also scales the model. ►



## Information Exchange

- ightarrow Data exchange via the clipboard
  - $\rightarrow$  Screenshot –
  - maximum data loss
  - → Paste special command the format can be selected
  - $\rightarrow$  Paste link –
  - the file can be edited with the original program
- ightarrow Data exchange using files
  - $\rightarrow$  intermediate file format (e.g. PDF, DXF, DWF) or
  - $\rightarrow$  native format of a more common program (e.g. DWG).

	Paste Special		? ×
	Source: AutoCA N:\_8ta	ND Drawing Object s_DAB\CAD 3D ArchShapes.dwg Default View As:	
<u> </u>	<u>Paste:</u> Paste link:	AutoCAD Drawing Object Picture (Enhanced Metafile) Bitmap	Display as icon
	Result ■	Inserts a new AutoCAD Drawing object into you file will be reflected in your document. <sup>Ie. Chan</sup> OK	r document. ges to the source Cancel

## **Pixelgrafic Formats**

ightarrow Biggest data loss / widest availability

 $\rightarrow$  Image capture (printscreen) or save

Most common formats currently:

PNG

- $\rightarrow$  lossless compression,
- $\rightarrow$  adjustable computational demand (time),
- $\rightarrow$  for line drawings (\_PNGOUT).

### JPG

- $\rightarrow$  lossy compression,
- ightarrow adjustable quality / loss,
- $\rightarrow$  for photos, rendered images (\_JPGOUT).

## **Data Exchange Formats**

**WMF** (Windows metafile)

- ightarrow clipboard equivalent,
- $\rightarrow$  can contain vector and raster graphic information,
- ightarrow the receiving application can choose the appropriate format,
- $\rightarrow$  created by export (\_WMFOUT),
- $\rightarrow$  background can be disabled (WMFBKGND).

**DXF** (Drawing Interchange Format)

- $\rightarrow$  CAD data exchange format (\_DXFOUT \_DXFIN),
- ightarrow almost all CAD programs can read/write it,
- ightarrow its use usually results in serious data loss.

## Web Formats

Mixed (pixel + vector) 2D formats  $\rightarrow$  Often created by "printing".

PDF (Portable Document Format)
→ for displaying documents faithfully
→ fonts + text information

 $\rightarrow$  pixel graphics (e.g. JPG)

**DWF** (Drawing Web Format)→ primarily for plans

 $\rightarrow$  vector graphic format + pixel graphic images



## Printing

Print settings...

- $\rightarrow$  Scale (\_ScaleListEdit)
- $\rightarrow$  Plot stamp
- $\rightarrow$  real printer/plotter or PDF/DWF converter
- ightarrow page size and output resolution
- $\rightarrow$  Print color and lineweight for ACI colors
- $\rightarrow$  Visual Style (e.g. hidden / rendered)

### \_SolProf

- ightarrow Creating an axonometric projection of a 3D model
- $\rightarrow$  Visible and hidden lines on separate layers (per viewport)
- → the 2D projections can be transferred to paperspace, antialiasing can be enabled.

Page setup			Plot style table (pen assignments)			
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## **CAD formats**

CAD data exchange formats (2D-3D)

 $\rightarrow$  For data exchange between CAD and render programs

 $\rightarrow$  can be created with exporting

#### DWG

- $\rightarrow$  Quasi-industry standard
- $\rightarrow$  Almost all CAD programs can read/write it

CAD viewer and editor Windows viewer

#### AUTODESK VIEWER

View now

#### View 3D designs in a browser

Autodesk Viewer supports most 2D and 3D files, including DWG, STEP, DWF, RVT, and Solidworks, and works with over 80 file types on any device. Get the feedback you need with Autodesk Viewer's annotation and drawing tools for easy online collaboration.

Online viewer

Over 80 file types	Works with	Platform	Key features
• DWG	✓ AutoCAD	<ul> <li>Browser-based</li> </ul>	✓ Measure
• STEP	✓ Revit	<ul> <li>Windows, Mac</li> </ul>	✓ Mark up
• DWF	<ul> <li>Fusion 360</li> </ul>	✓ Chrome OS	✓ Share
and more	and more		

## **OpenGL Data Exchange**

Capturing OpenGL information of 3D geometry, texture, lights...



T:\o6\$ 8tas tav\SzaAlk2\Ea5 CAD\HobbitHaz3D+.dwf-Windows Internet Explorer

T:\o6\$ 8tas tav\SzaAlk2\Ea5 CAD\HobbitHaz3D+.dwf

0-

Image: Ima

## CAD > Script, Macro

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## **Automatization Levels**

enath : 15 66

- $\rightarrow$  A program module is a procedure written in programming language (AutoLisp, VBA...).
- $\rightarrow$  ActiveX enables you to manipulate AutoCA e.g. from an Excel VBA.
- $\rightarrow$  A macro (Action Macro, ACTM) is a recorded command sequence.
- $\rightarrow$  Buttons and menus can be customized using DIESEL\* expressions.
- $\rightarrow$  A script is a list of program instructions.
- $\rightarrow$  Command aliases can be used (PGP), or can be customized.

\* Dumb Interpretively Evaluated String Expression Language

n	in a	A Customize User Interface						×
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## **AutoCAD Script**

The purpose of the script is usually to automate repetitive processes, command sequences...

- $\rightarrow$  can be started with the Script command or copied directly to the command line,
- $\rightarrow$  the SCR file's default folder is the drawing's folder.

Can be created in a text editor (e.g. Notepad++) — mustn't contain formatting codes (no docx).

The Enter character (CR/LF) can be replaced by a space (Space),

- ightarrow commands can be written in one line, the script is clearer and shorter,
- $\rightarrow$  the separation of parameters is more difficult to notice.

Can contain any number of instructions, but an error can derail it.

- $\rightarrow$  the Undo undoes the entire script,
- → debugging is easier if it's broken down into shorter files.
   Use and understanding are aided by the use of eloquent names, comments, and explanations.

## **Parametric Script**

#### Spiral staircase steps

- ightarrow Copying, rotating and lifting
- $\rightarrow$  Parameters specified in a spreadsheet
  - $\rightarrow$  Inner radius  $\rightarrow$  r<sub>1</sub> = 60 cm
  - $\rightarrow$  Outer radius  $\rightarrow$  r<sub>2</sub> = 200 cm
  - $\rightarrow$  Step angle  $\rightarrow \phi = 18^{\circ}$
  - $\rightarrow$  Step width  $\rightarrow$  th = 5 cm
  - $\rightarrow$  Step height  $\rightarrow$  ht = 15 cm



BME Faculty of Architecture Department of Morphology and Geometric Modeling

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