

Grafică asistată de calculator



Curs și laborator

Curs:

Constantin Nandra, Sl. Dr. Ing.

Departamentul Calculatoare

Universitatea Tehnică din Cluj-Napoca

Website: <https://users.utcluj.ro/~cosminnandra>

E-mail: constantin.nandra@cs.utcluj.ro

Suport curs:

Moodle (<https://moodle.utcluj.ro>), modulul:

“Elemente de Grafică Asistată de Calculator, Seria B, Sem. 2, 2024/2025”

Birou:

Sala C5 (mansardă) - Str. G. Barițiu, nr. 26-28

Curs și laborator

Laborator:

Yours truly

Victor Bâcu, Conf. Dr. Ing.

Maria Vasilache, Ing.

Vlad Boancă, Ing.

Maria Pașca, Ing.

Sali: 210, 213 – Clădirea UTCN, Strada Observatorului nr. 2,

Sistem de notare

E => Examen scris: pondere in nota finală: 60%
pentru promovare, E>=?

L => Notă laborator: pondere in nota finală: 40%
pentru promovare, L>=5.0

AC => Activitatea la curs: 10%

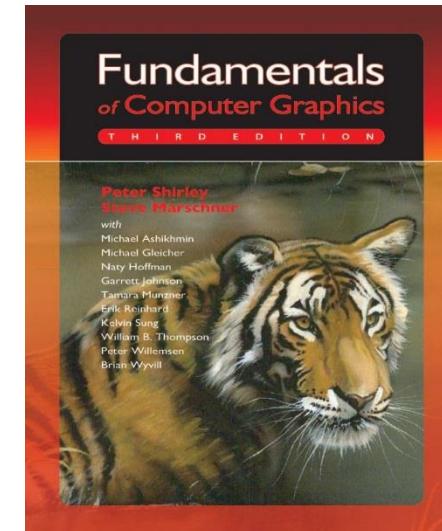
Nota finală: $0,6 * E + 0,4 * L + 0,1 * AC$
pentru promovare, Nota finală >=5.0

Referințe

Fundamentals of Computer Graphics

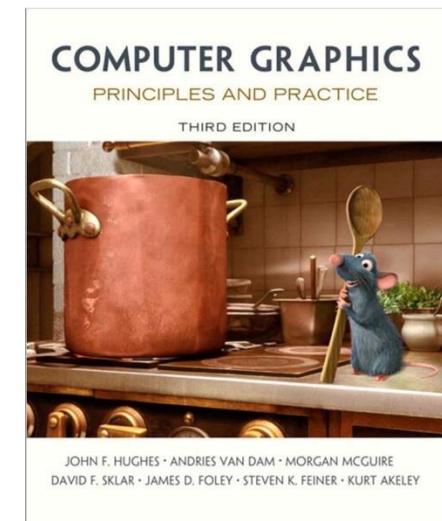
Autori: Peter Shirley, Michael Ashikhmin, Steve Marschner

Editura: A K Peters/CRC Press, 2009



Computer Graphics: Principles and Practice (3rd Edition)

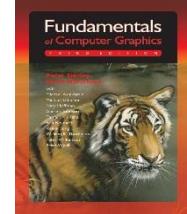
Autori: John F. Hughes, Andries van Dam, Morgan McGuire, David F. Sklar, James D. Foley, Steven K. Feiner, Kurt Akeley
Editura: Addison-Wesley Professional, 2013



Grafica asistată de calculator

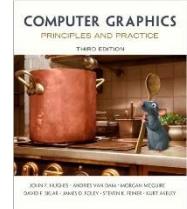
Grafica asistată de calculator cuprinde orice utilizare a calculatorului pentru crearea și manipularea imaginilor

(Peter Shirley et al., *Fundamentals of Computer Graphics*)

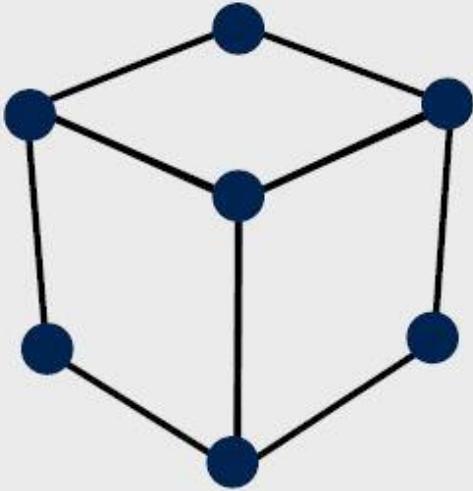


Știința și arta comunicării vizuale prin intermediul unui dispozitiv de afișare al unui calculator și dispozitivele acestuia de interacțiune

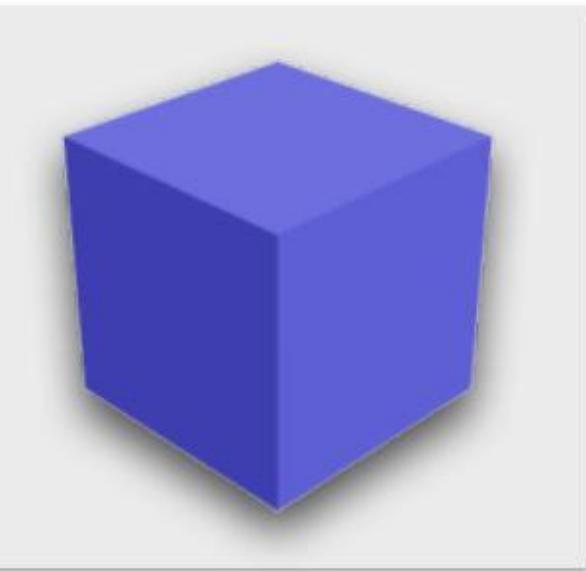
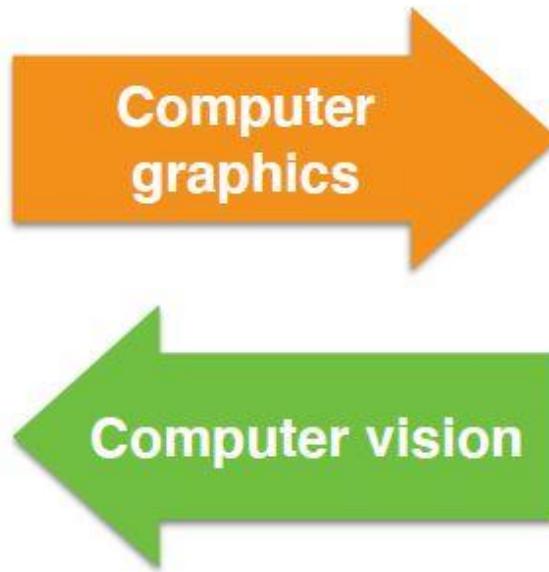
(John F. Hughes et al., *Computer Graphics: Principles and Practice* (3rd Edition))



Objectiv



**Geometric model
representation**



Digital image

Imagine reală sau generată?



Imagine reală sau generată?

Generată



Reală



The file is 37 Teletypes. Dial
in at 37 baud. It is delivered to the 382
and 37 is converted to a 382.
382 is then converted step by step to a 5 crossover to a
382 connecting at 100 baud.

Maria: wow

[14-Jul-13 19:29] guest29 on tty0 has joined.

[rbigio] I don't know if its because I'm on broadband at home but the data trans
isnt as good as it was on the public bbs. I think it's because

[maria] its good

[rbigio] That's why I though we were at first emulating a BBS until smj reminds
me this is going to be teletype. I'd better type more carefully. it
smj] yep there is a fine line (but a line) between retro and authentic.

[pimental] There will be the video as well, you'll love to see that online.

[rbigio] So here please say another photo to see them in action.

[pimental] Twitter.com/sdf/pubpix say another photo to see them in action.

[14-Jul-13 19:33] guest30 on tty7 has joined.

[guest30] Hello everyone! Maria!

[rbigio] BBL Not feeling well. Going for a nap.

[14-Jul-13 19:35] guest28 on ttyb has left.

[pimental] May we paste ASCII art?

[smj] the 37s do not auto-wrap (yet)

[smj] the camera is rolling, everyone say hi!

[pimental] Hi MOM!

[handyc] Hello camera!

[maria] good morning

[zeptar] hi

[smj] hold on, I'll type an @Who on the 37.

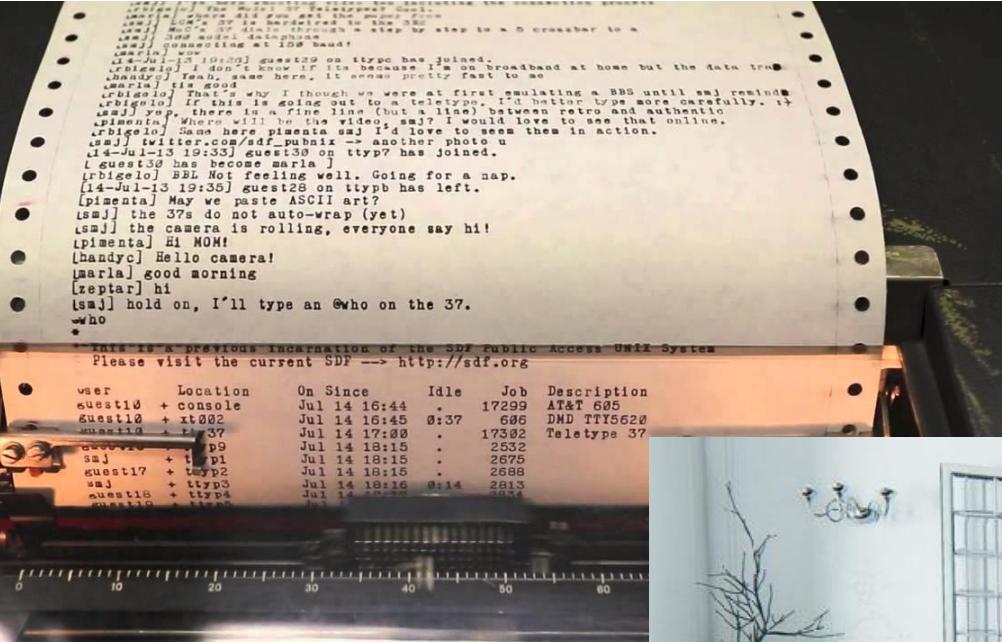
[who]

* THIS IS A PREVIOUS INCARNATION OF THE SDF PUBLIC ACCESS UNIX SYSTEM
Please visit the current SDF --> <http://sdf.org>

User	Location	On Since	Idle	Job	Description
guest10	+ console	Jul 14 16:44	.	17299	AT&T 605
Guest10	+ xt022	Jul 14 16:45	0:37	606	DMD TTY5620
guest13	+ 37	Jul 14 17:00	.	17302	Teletypes 37
smj	+ p9	Jul 14 18:15	.	2532	
smj	+ p1	Jul 14 18:15	.	2675	
guest17	+ t022	Jul 14 18:15	.	2688	
smj	+ tty3	Jul 14 18:16	0:14	2813	
guest18	+ tty4	Jul 14 18:16	.	2814	
guest10	+ tty5	Jul 14 18:16	.	2815	



Computer output



-> Output of Teletype

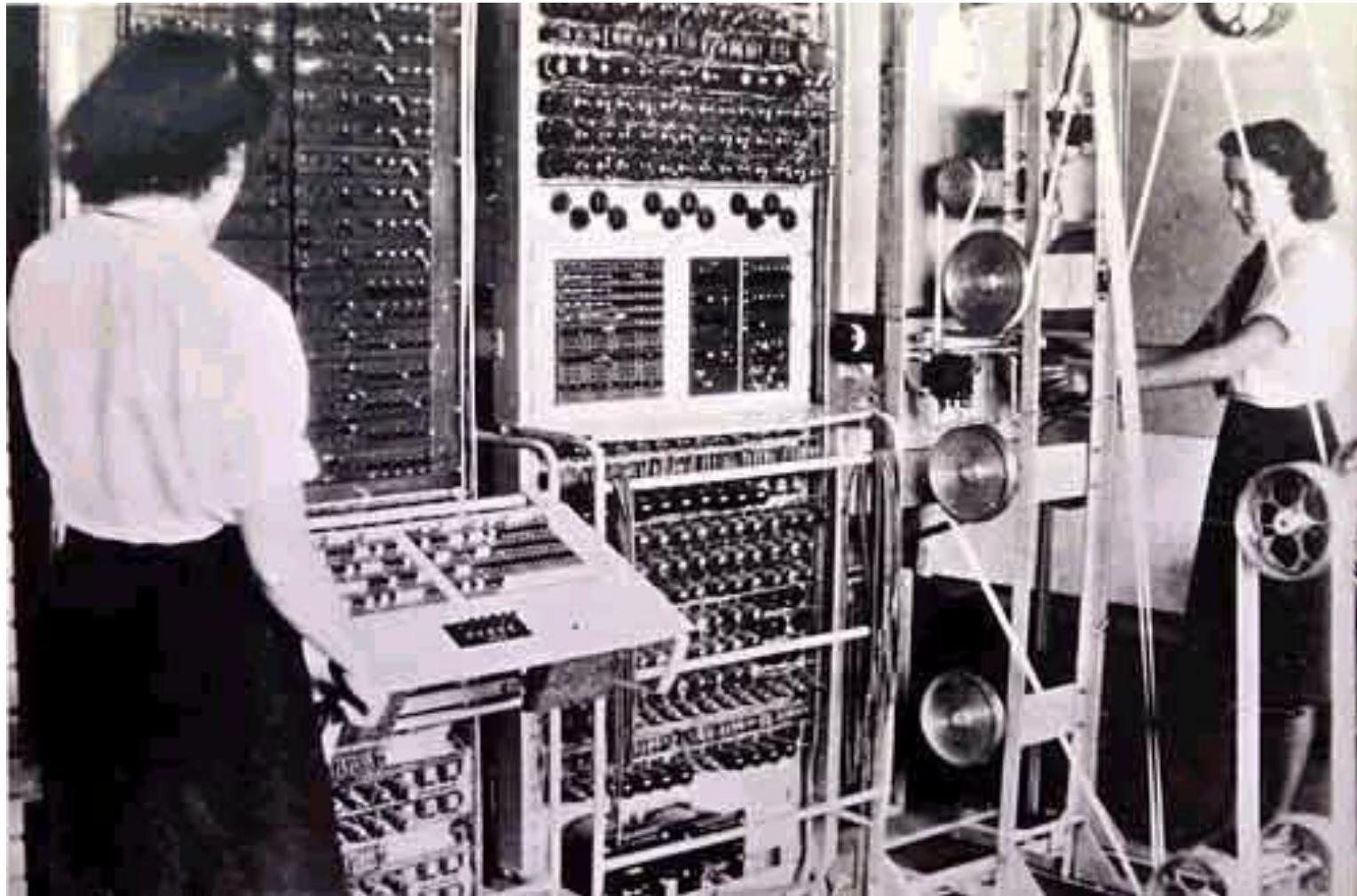


Output of Unreal Engine ->

Istorie

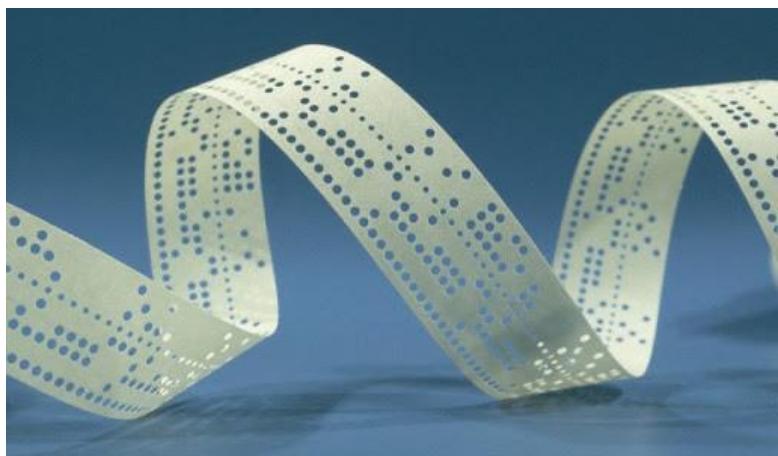


Istorie



Colossus Computer

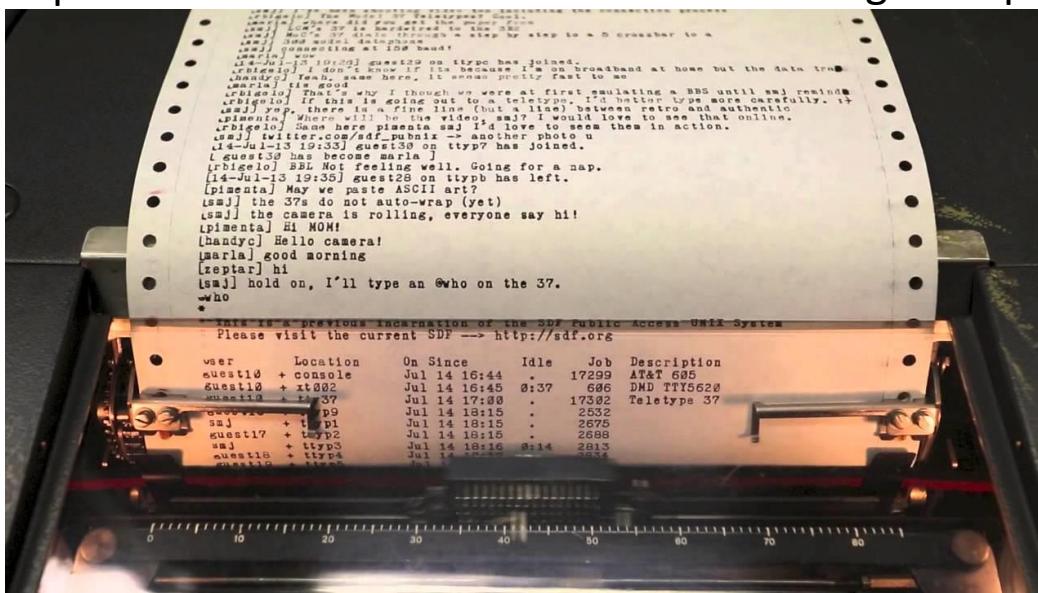
Istorie



Punch tape



Analogue display



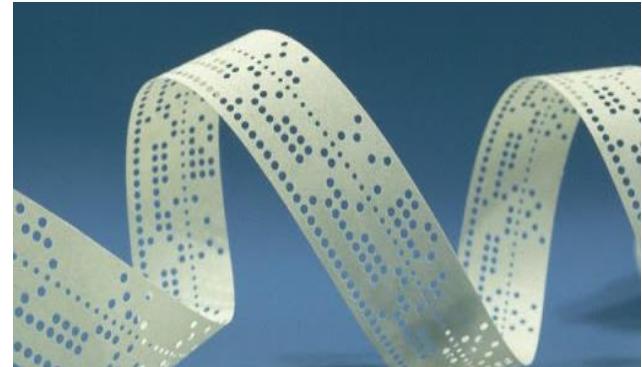
User	Location	On Since	Idle	Job	Description
guest10	+ console	Jul 14 16:44	.	17299	AT&T 605
guest10	+ xt802	Jul 14 16:45	0:37	606	DMD TTY5620
guest10	+ t37	Jul 14 17:00	.	17302	Teletype 37
smj	+ p9	Jul 14 18:15	.	2532	
smj	+ t1	Jul 14 18:15	.	2575	
guest17	+ tmy2	Jul 14 18:15	.	2569	
smj	+ ttyp3	Jul 14 18:16	0:14	2813	
guest10	+ ttyp4	Jul 14 18:16	.	2834	

Teletype

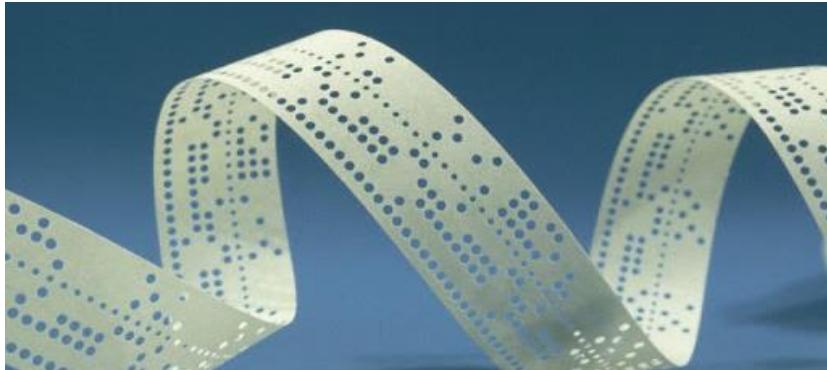
Istorie



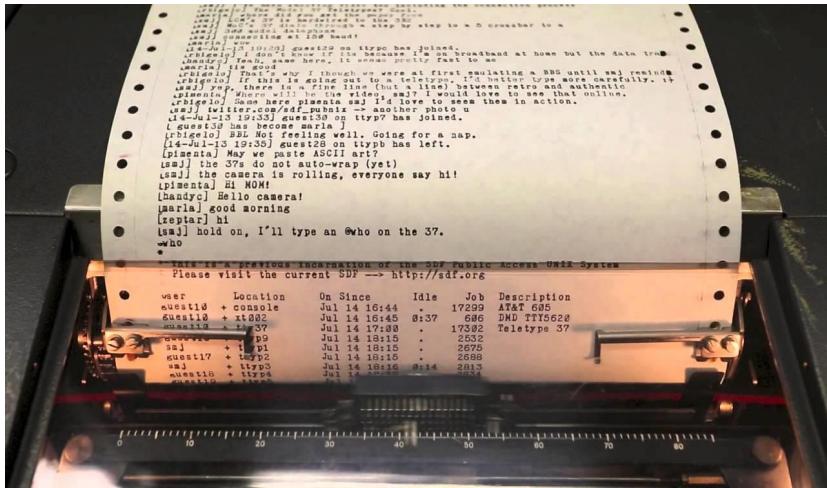
Margaret Hamilton stands next to a stack of program listings from the Apollo Guidance Computer, photograph taken in 1969. [Wikimedia Commons](#)



Istorie



Grandpa's/Grandma's code



Grandpa's/Grandma's DEBUGGING TOOL

Food for thought

(Buff Doge): “I debugged with paper printed logs and wrote code using punch tape”

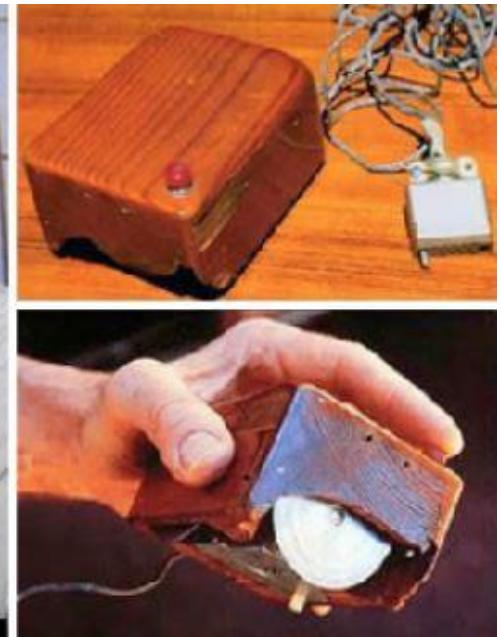
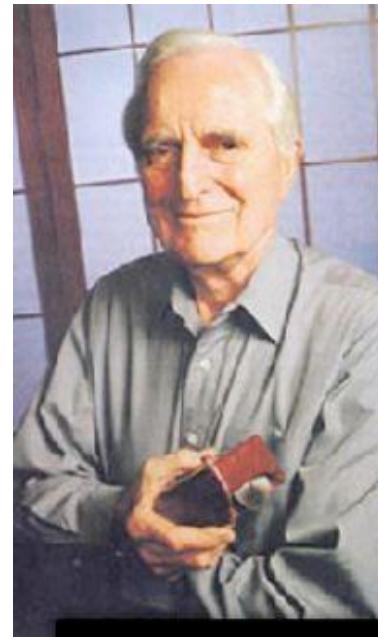


(Crying Doge): “I use printf because learning to use a debugger is too much effort.”

Istorie

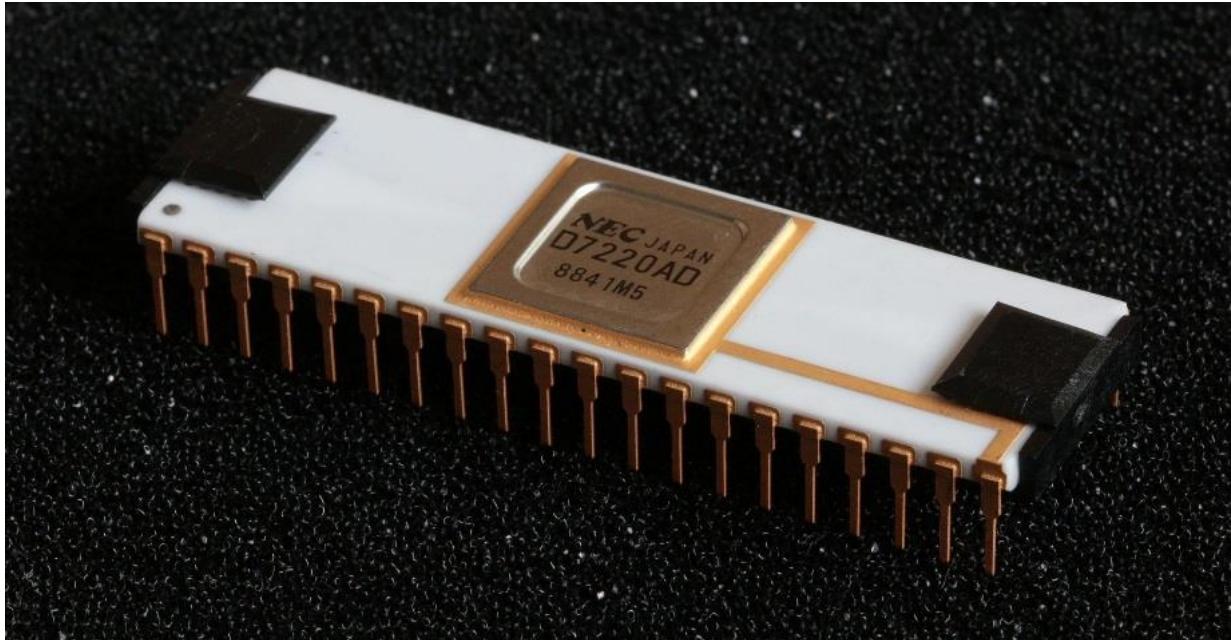


Xerox Star - 1981



Prototip de mouse
realizat de Doug Engelbart (1963)

Istorie

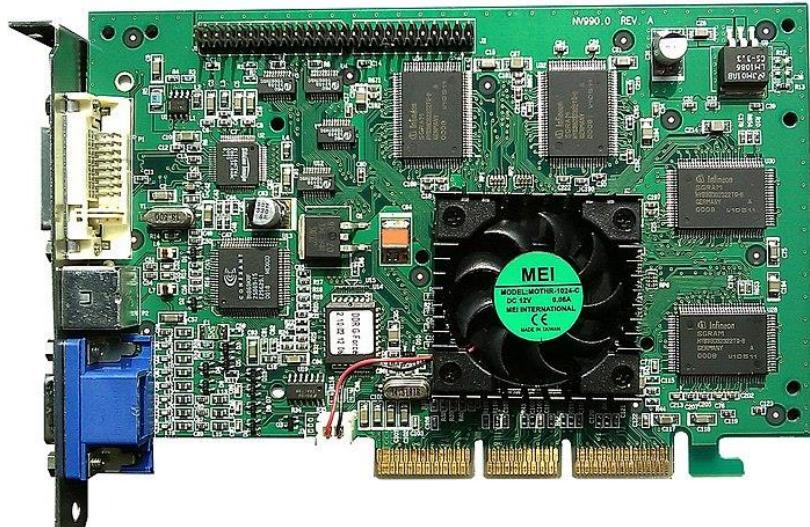


NEC μPD7220 – Primul procesor grafic realizat sub forma unui circuit integrat LSI (1982)

Desenare: linii, cercuri și caractere într-o zonă de memorie conectată la display

Istorie

Nvidia GeForce 256 – marketed as a GPU –
“Graphics Processing Unit” - 1999



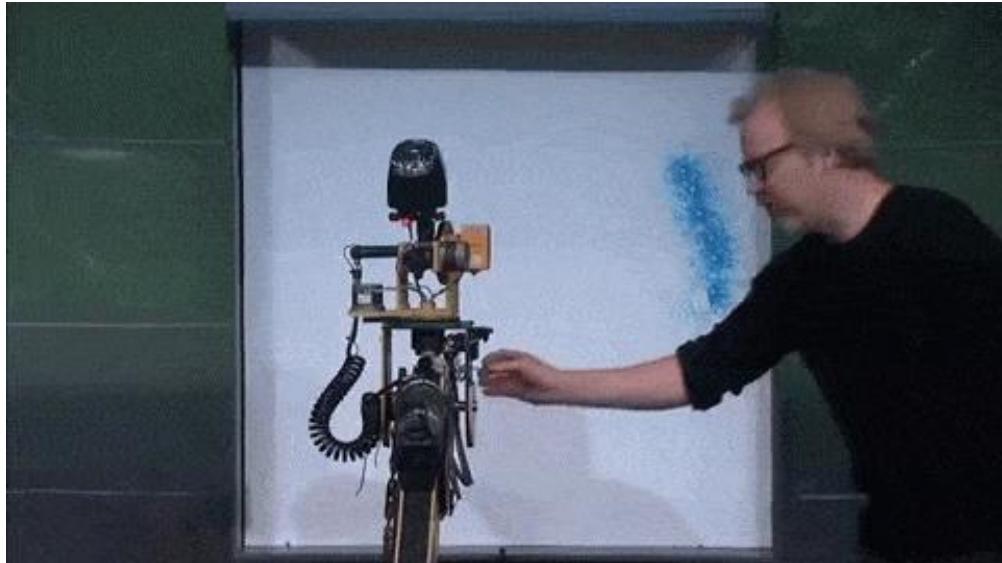
ATI Radeon 9700 (2002)

Unified Shader Architecture



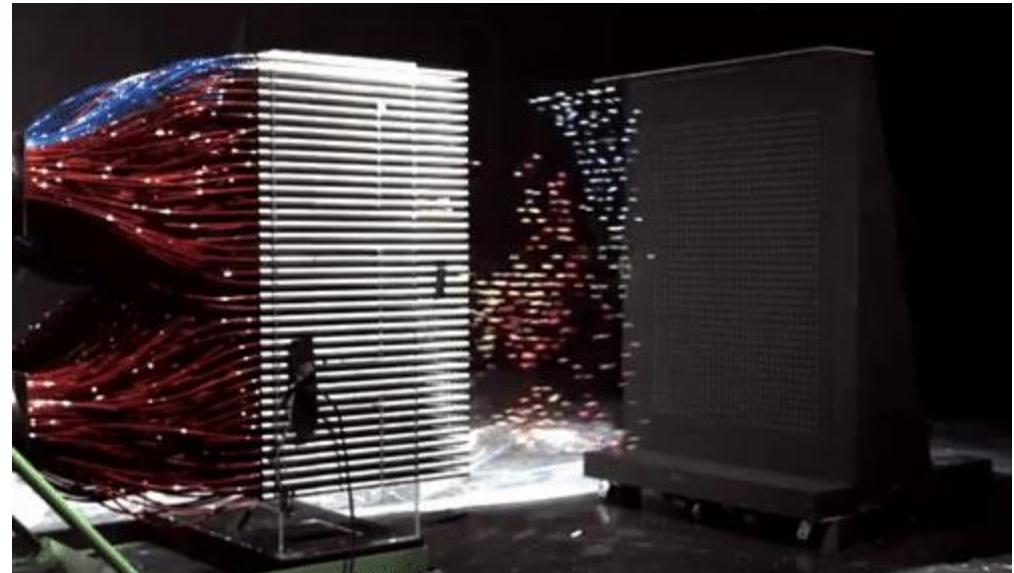
NVIDIA GeForce3 Ti 200 (2001)

CPU vs. GPU

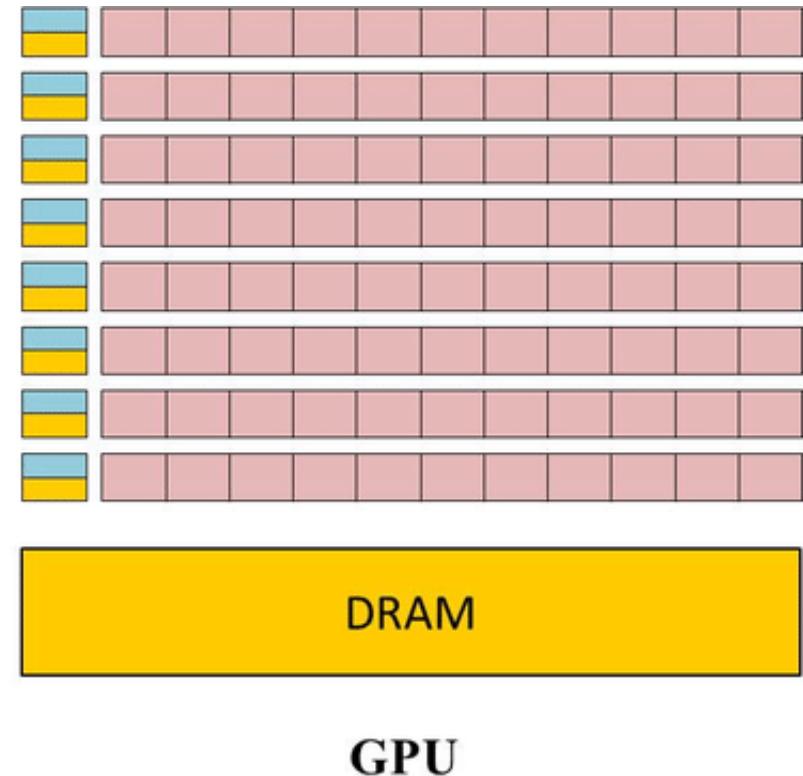
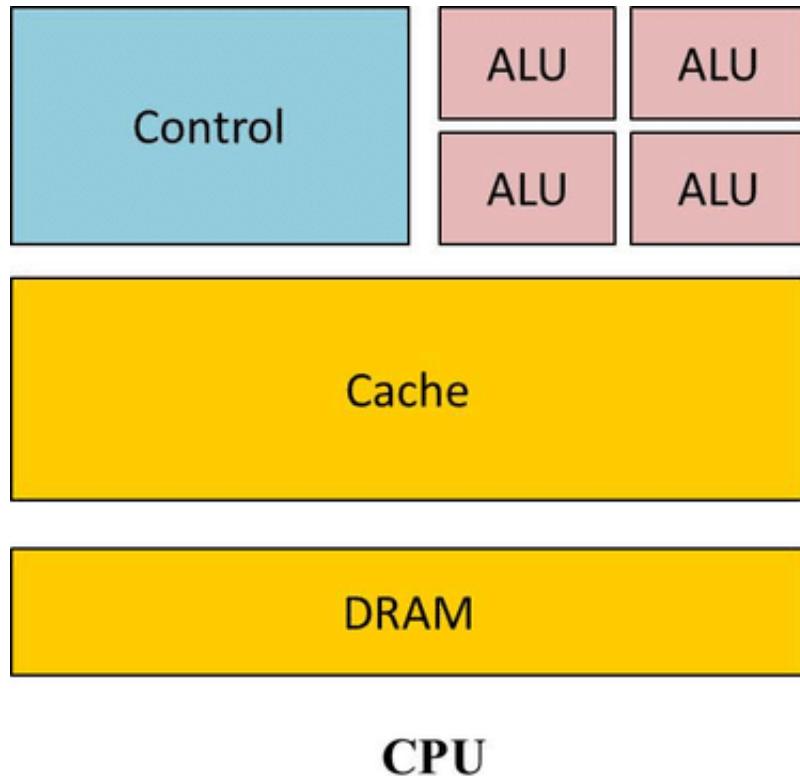


CPU

GPU



CPU vs. GPU

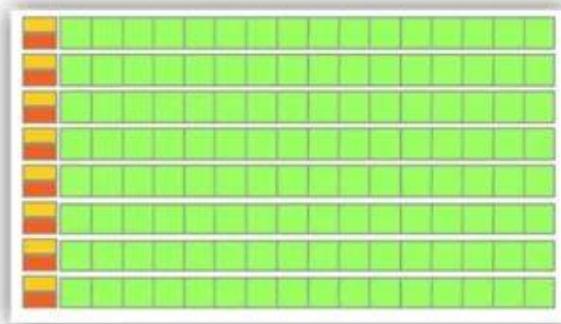


CPU vs. GPU

CPU



GPU



- * Low compute density
- * Complex control logic
- * Large caches (L1\$/L2\$, etc.)
- * Optimized for serial operations
 - Fewer execution units (ALUs)
 - Higher clock speeds
- * Shallow pipelines (<30 stages)
- * Low Latency Tolerance
- * Newer CPUs have more parallelism

- * High compute density
- * High Computations per Memory Access
- * Built for parallel operations
 - Many parallel execution units (ALUs)
 - Graphics is the best known case of parallelism
- * Deep pipelines (hundreds of stages)
- * High Throughput
- * High Latency Tolerance
- * Newer GPUs:
 - Better flow control logic (becoming more CPU-like)
 - Scatter/Gather Memory Access
 - Don't have one-way pipelines anymore

Grafica Asistată de Calculator: Progres iterativ

- Roberts (1963), Appel (1967) - **hidden-line algorithms**
- Warnock (1969), Watkins (1970) - **hidden-surface algorithms**
- Gouraud (1971) - **diffuse lighting**
- Phong (1974) - **specular lighting**
- Blinn (1974) - **curved surfaces, texture**



[Pixar Shutterbug Image Series]

Grafica Asistată de Calculator: Progres iterativ

- Catmull (1974) - **Z-buffer hidden surface algorithm**
- Crow (1977) - **anti-aliasing**
- Whitted (1980) - **ray tracing**
- Goral, Torrance et al. (1984), Cohen (1985) - **radiosity**
- Perlin (1985) - **shading languages**
- Drebin et al. (1988), Levoy (1988) - **volume rendering**



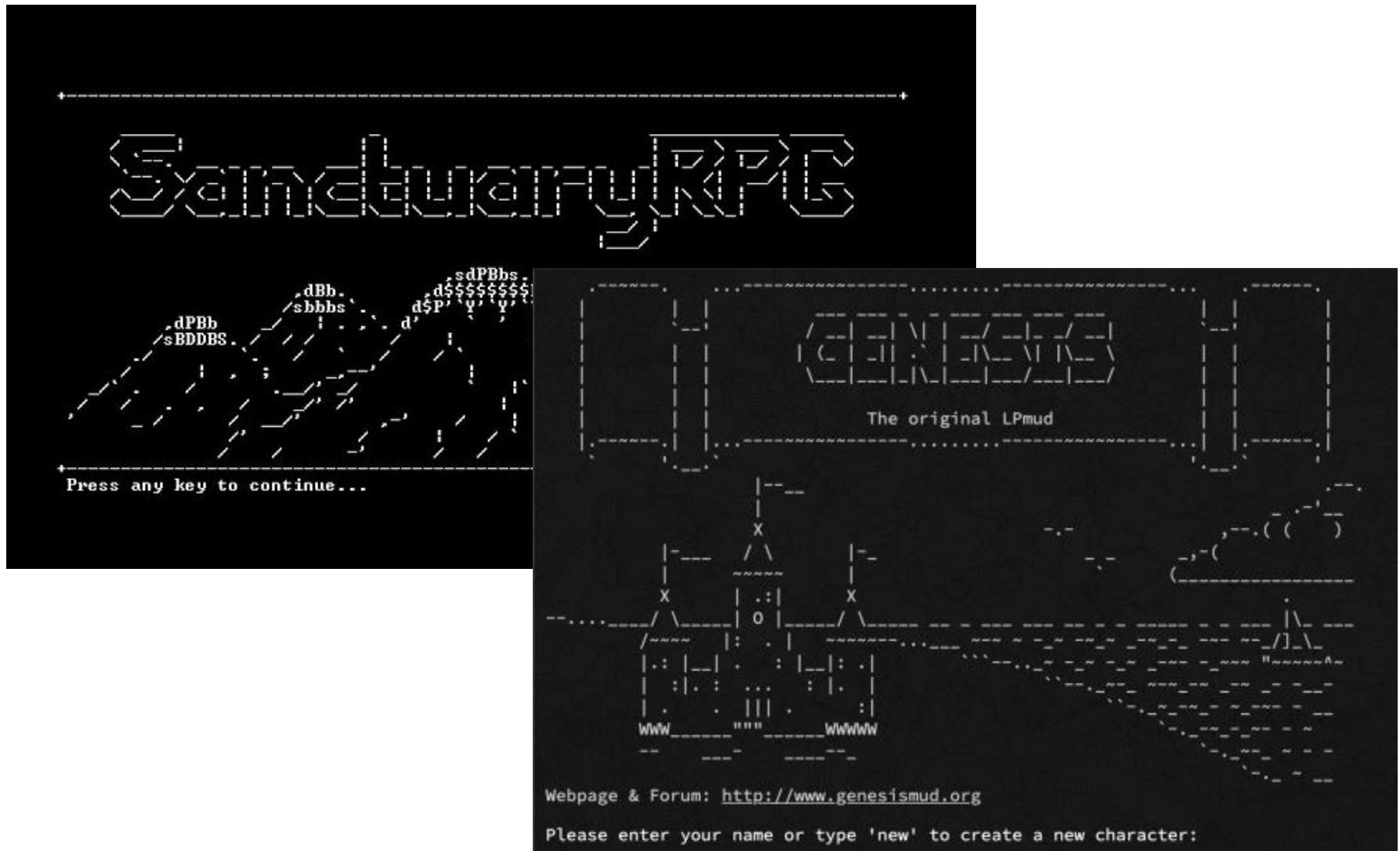
[Pixar Shutterbug Image Series]

Stadiul actual

- Displacement mapping
- Environment mapping
- Ray tracing
- Photon mapping
- Particle systems



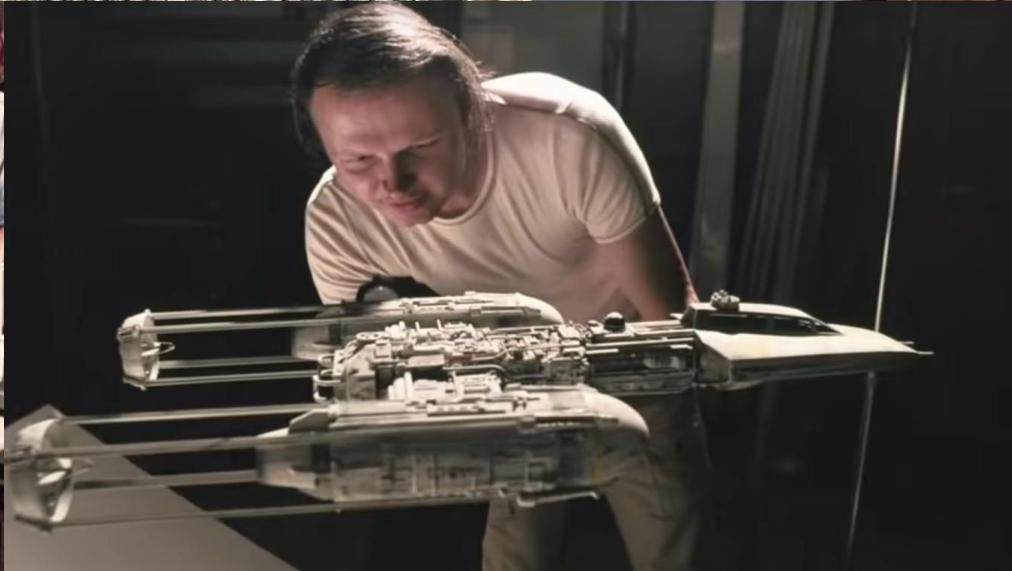
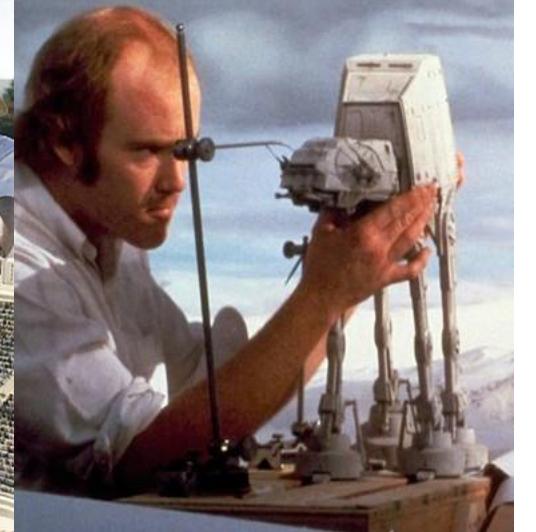
Grafica Asistată de Calculator: Jocuri



Grafica Asistată de Calculator: Jocuri



Grafica Asistată de Calculator: Cinema (VFX)



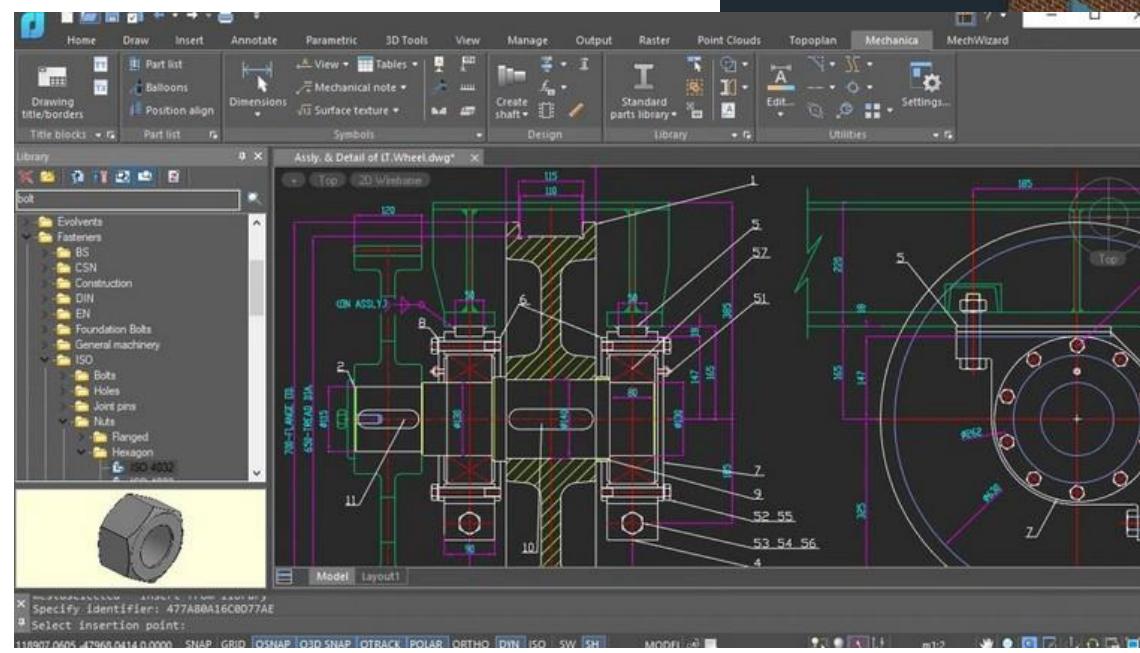
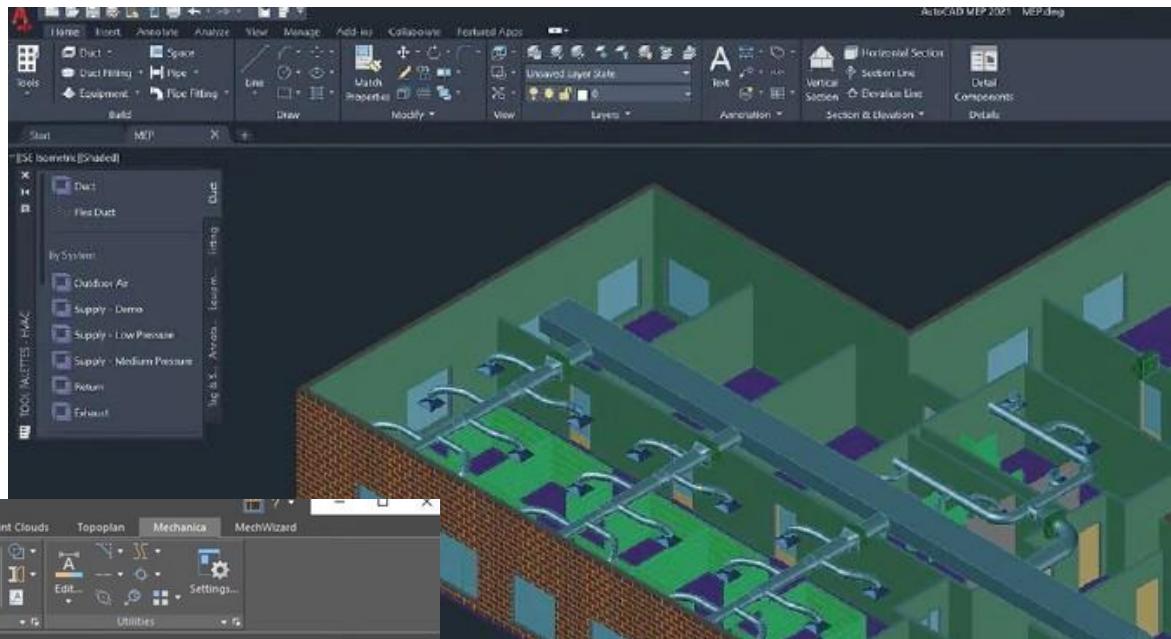
Grafica Asistată de Calculator: Cinema (VFX)



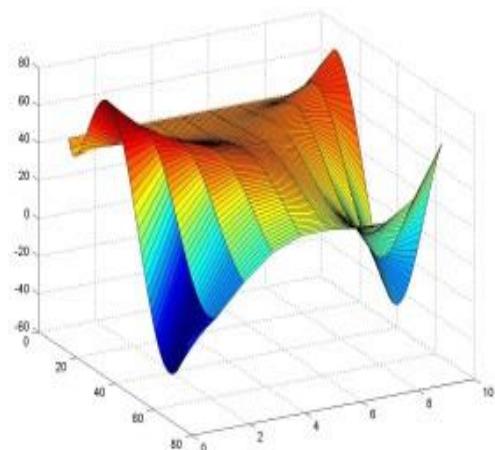
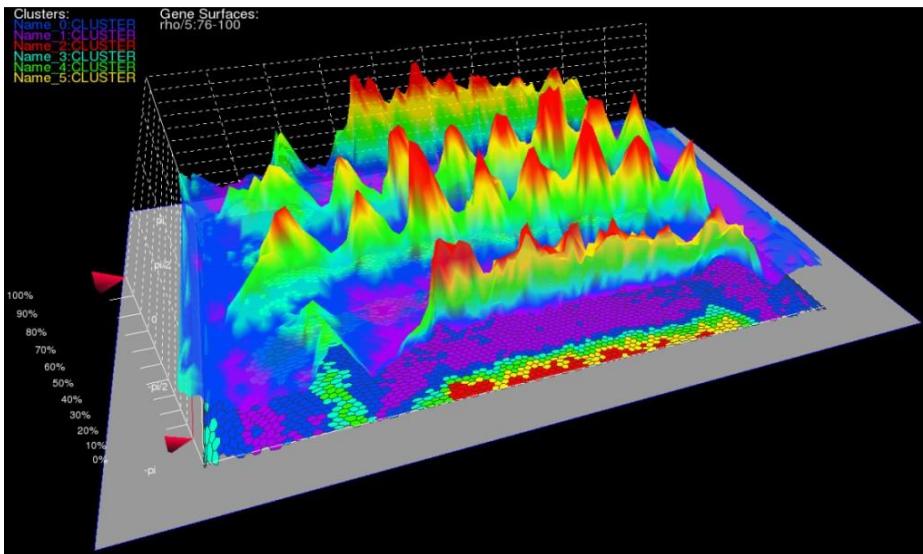
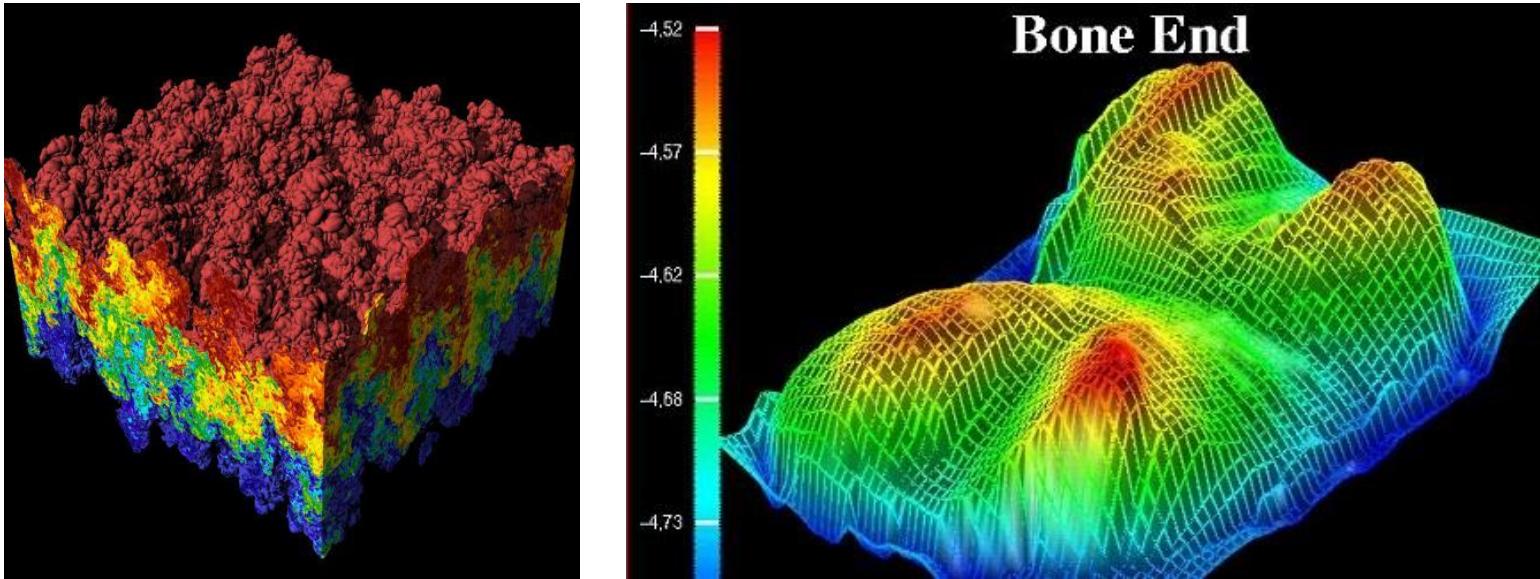
Grafica Asistată de Calculator: Computer Aided Design (CAD)



Grafica Asistată de Calculator: Computer Aided Design (CAD)



Grafica Asistată de Calculator: Vizualizarea datelor



Grafica interactivă

Permite utilizatorului să controleze **conținutul, structura și aspectul** obiectelor prin feedback vizual (în timp real)



Non-interactivă

Axată pe fotorealism – utilizează algoritmi de trasare de complexitate sporită

Ex: Ray-tracing



Non-interactivă

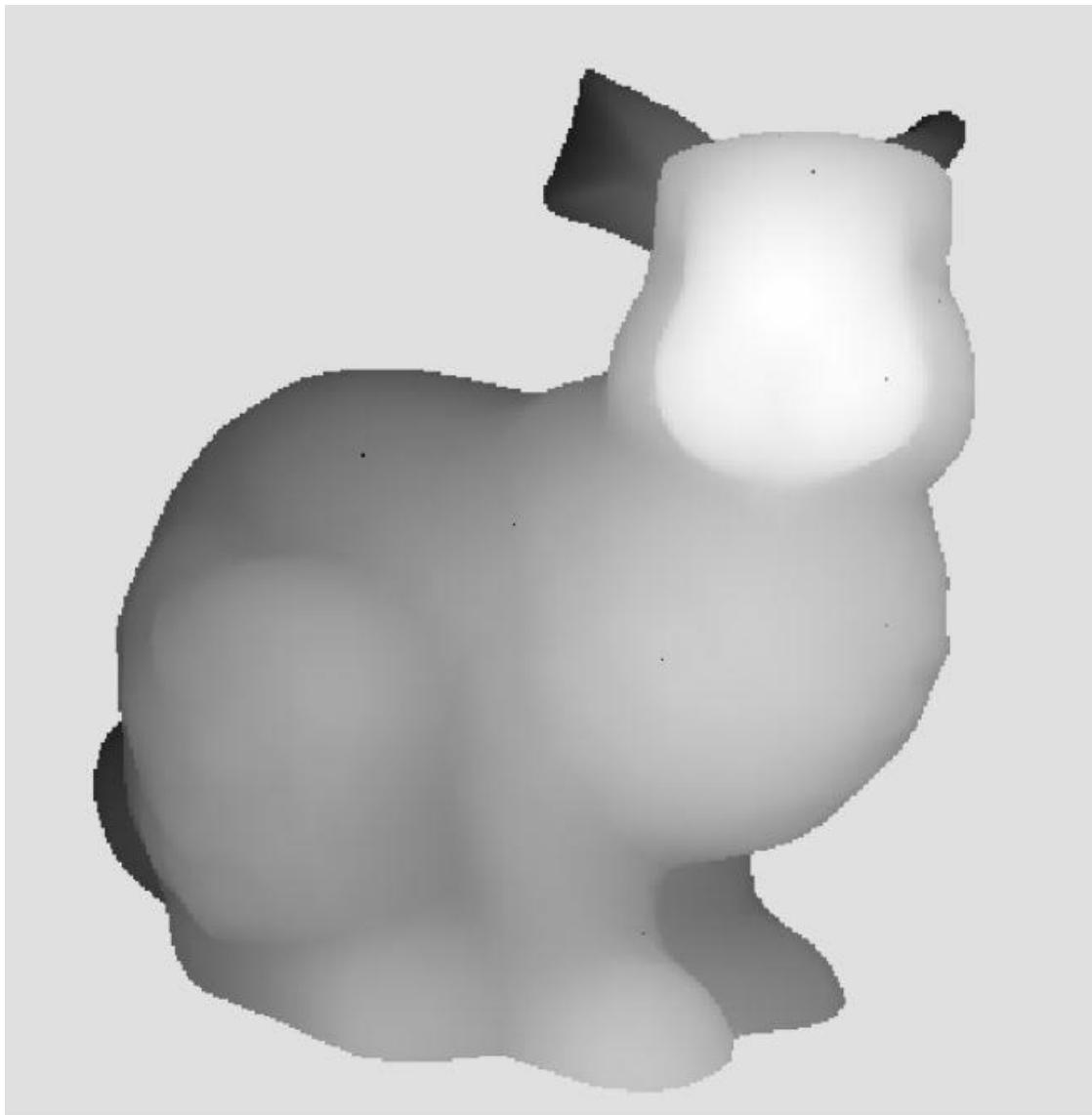
Durata medie de trasare a unui singur cadru din filmul de animație Cars 2:
11.5 ore

Astfel de trasări grafice se realizează utilizând “ferme de trasare” (render farms), cu multiple nuclee de procesare: 1000, 5000, 10000, etc.



[Pixar's Cars 2]

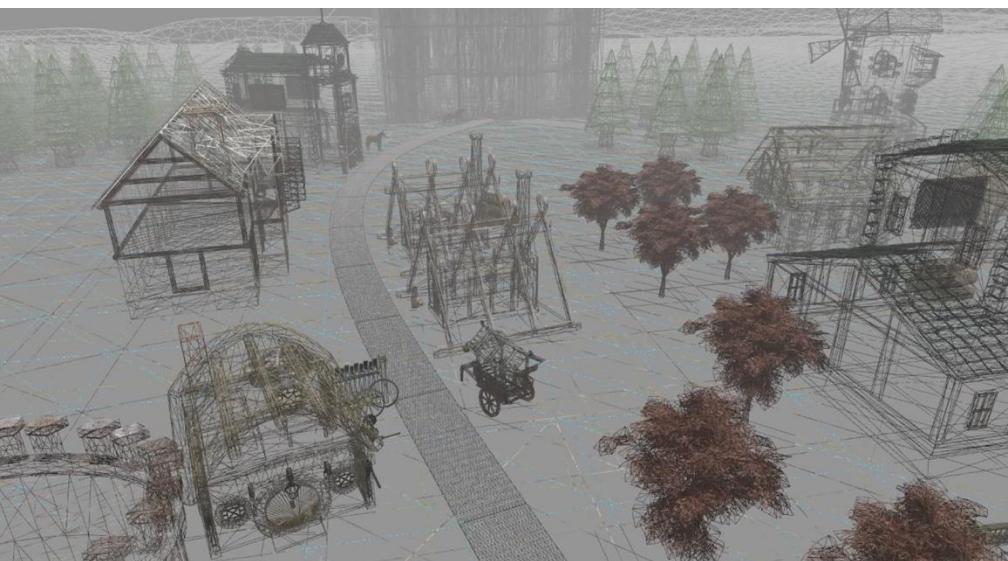
Realizări



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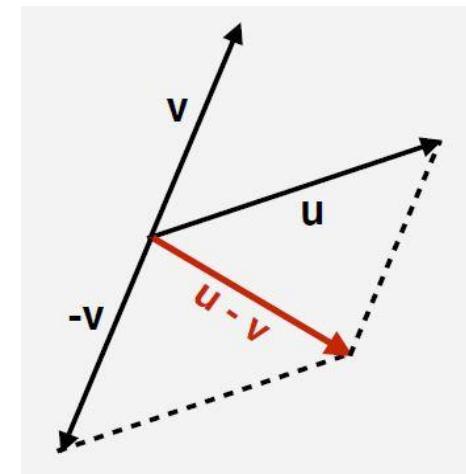
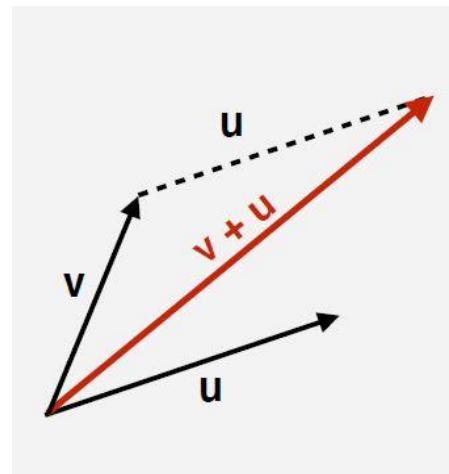
Structura cursului

- **Introducere**
- Noțiuni de matematică
- Transformări
- Transformarea de vizualizare
- Decupare
- Rasterizare
- Pipeline grafic
- Procesarea fragmentelor
- *Modelare
- *Formate grafice
- *Animatie

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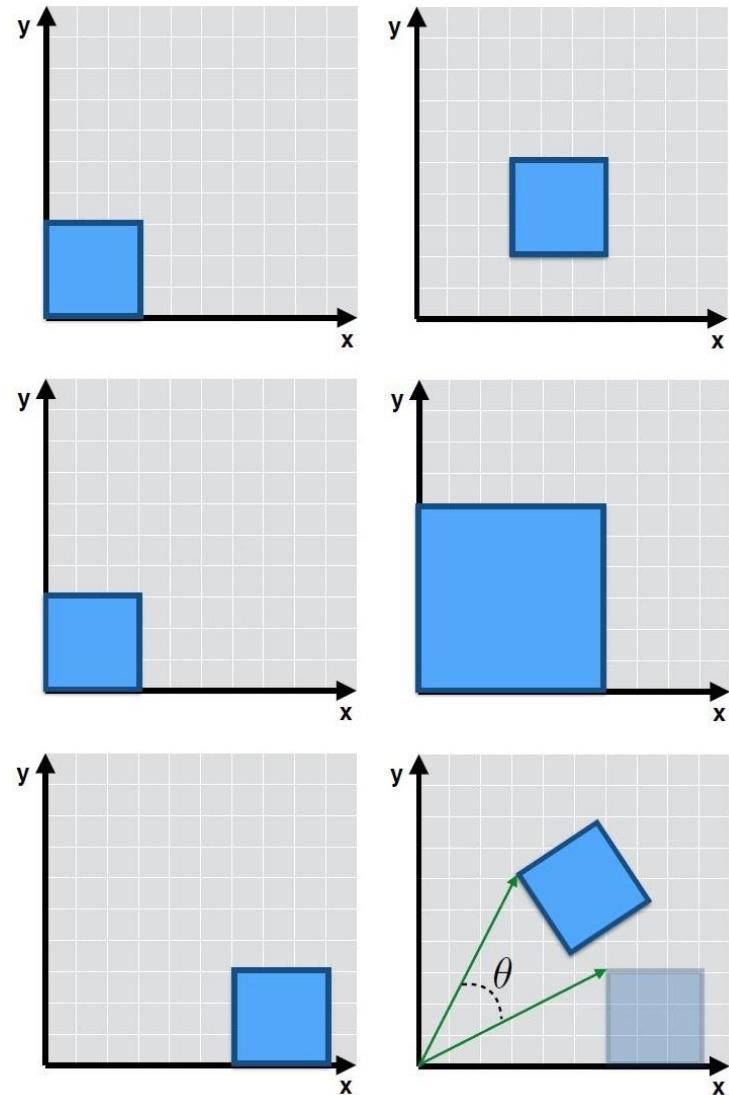
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$$v = \begin{bmatrix} x_1 \\ y_1 \\ z_1 \end{bmatrix} \quad u = \begin{bmatrix} x_2 \\ y_2 \\ z_2 \end{bmatrix}$$



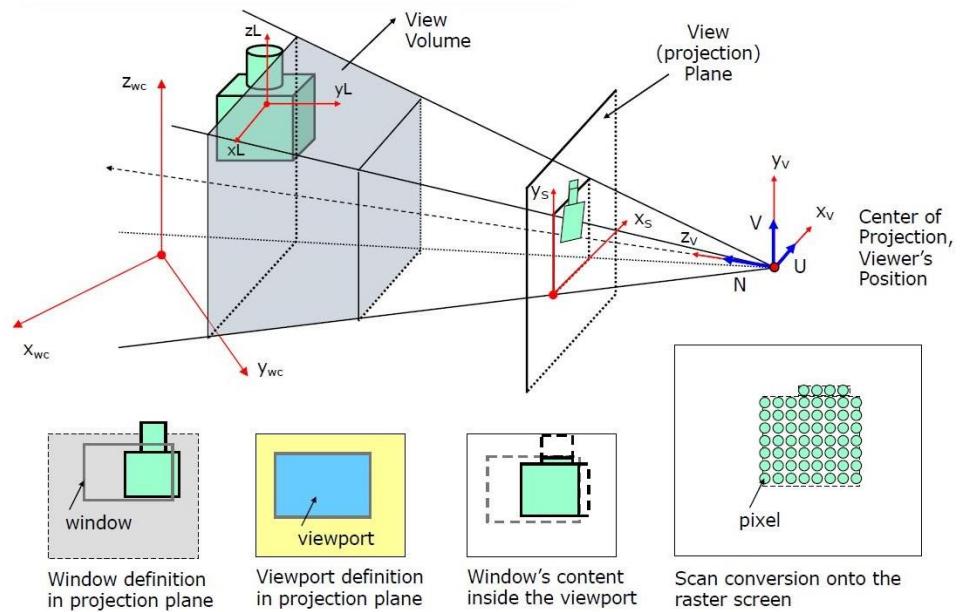
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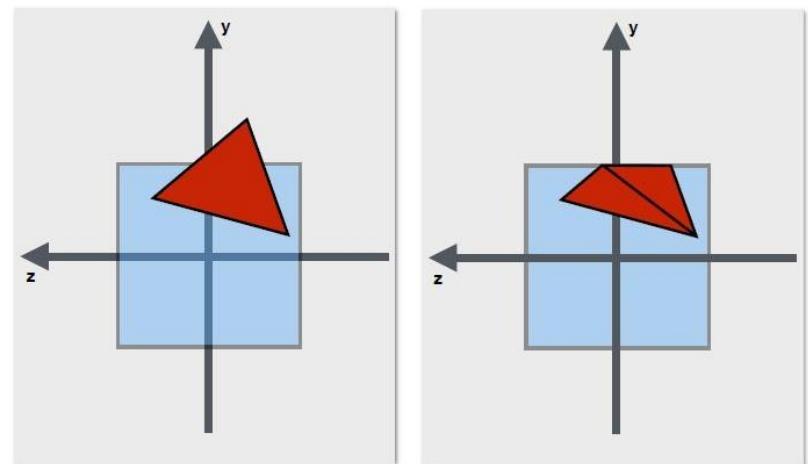
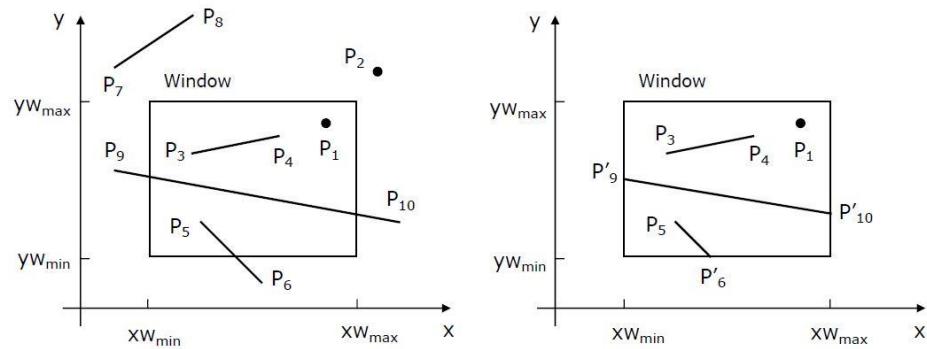
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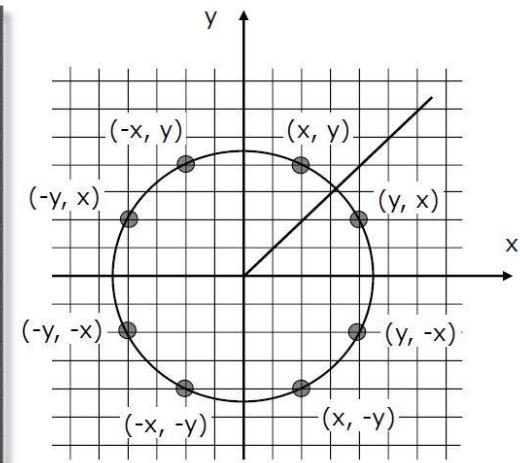
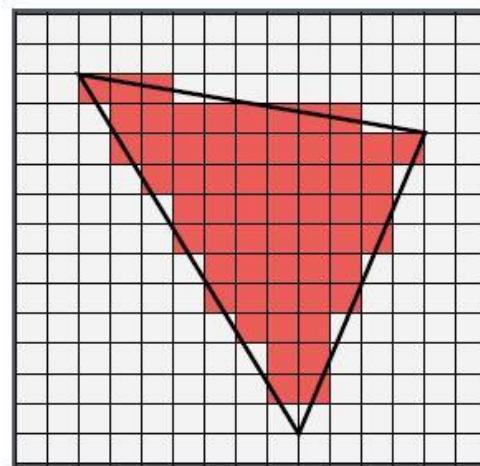
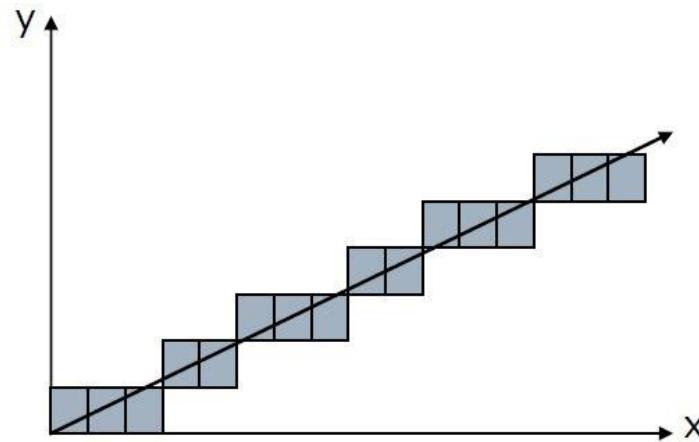
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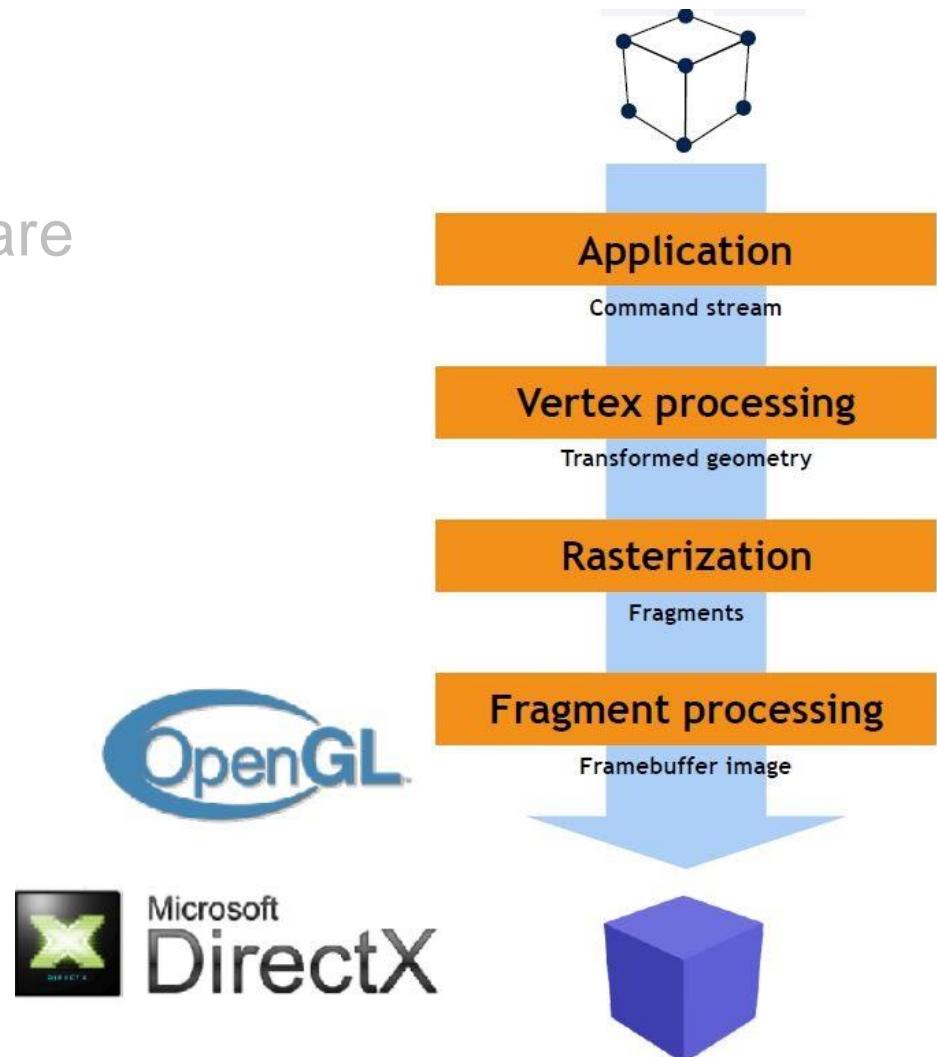
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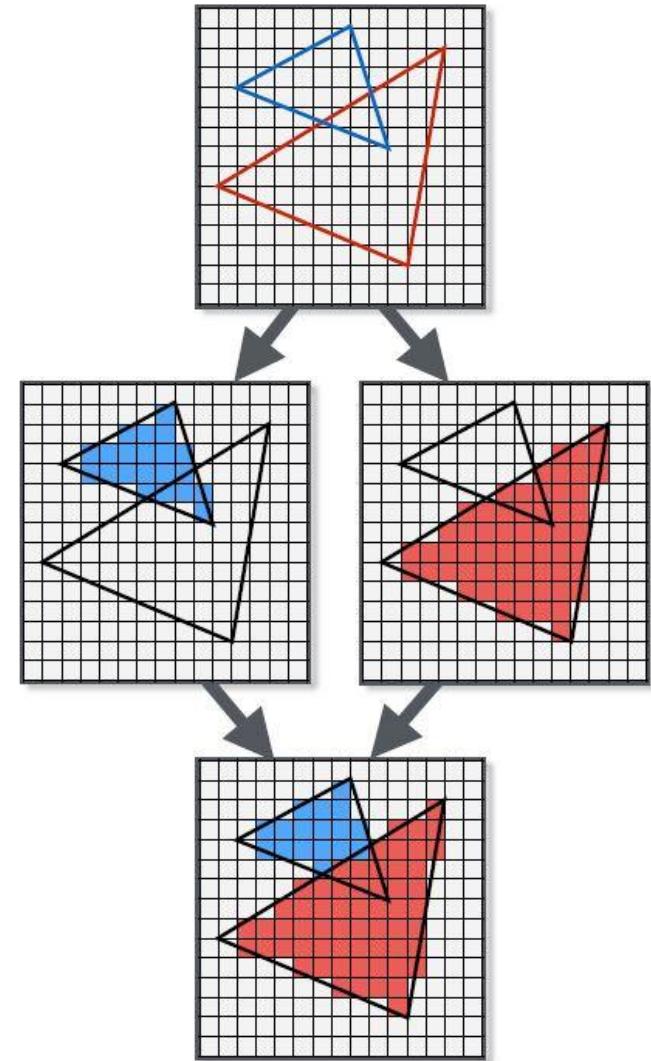
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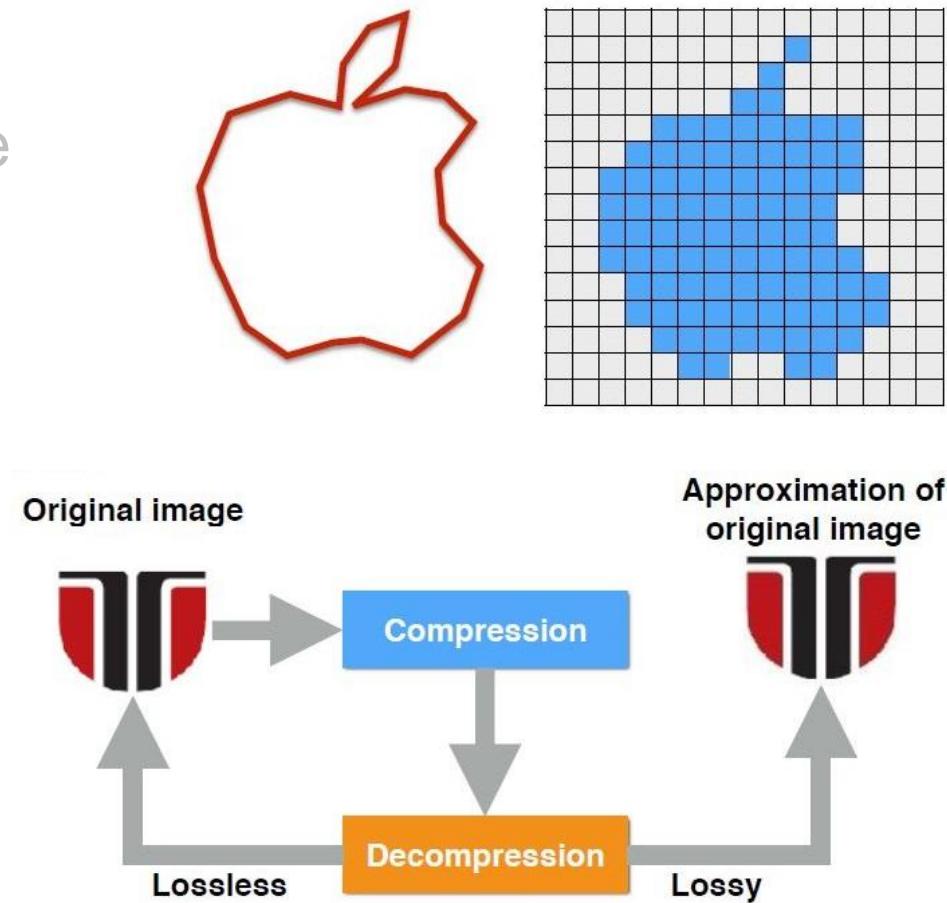
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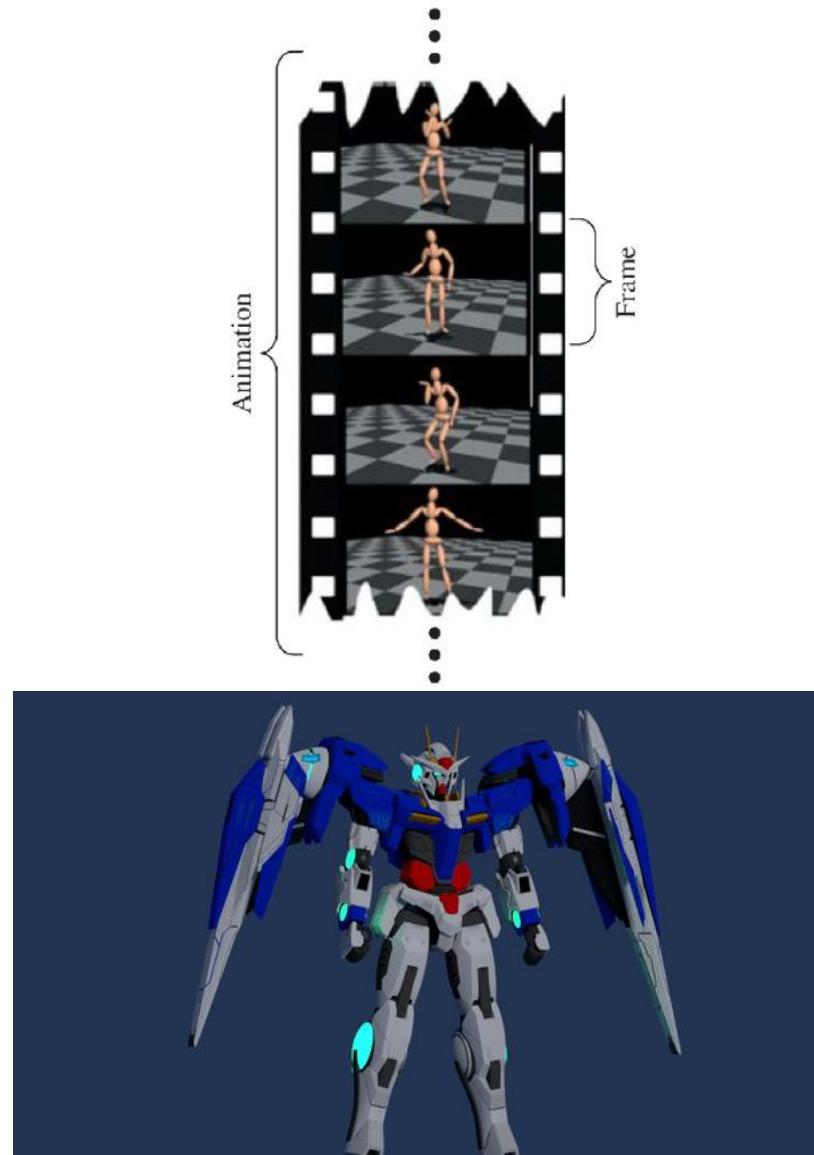
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Structura laboratoarelor

- Introducere în SDL
- Noțiuni de matematică implementate: vectori
- Noțiuni de matematică implementate: matrice
- Transformări grafice
- Algoritmi de decupare pentru primitive grafice
- Transformări de vizualizare
- Rasterizarea liniilor/cercurilor – Bresenham
- Rasterizarea triunghiurilor – coordonate baricentrice
- Eliminarea suprafețelor ascunse (Z-Buffer, back-face culling)