

Project Group:
Vector Graphics on Modern Hardware
(VGMH)

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<https://git.cs.uni-paderborn.de/vgmh/info>

Canonical example



"Ghostscript tiger"

Motivation

Why are the quantum computing people doing a project group on vector graphics?

Def: TCount

Input: circuit U , integer k , real $\epsilon = \frac{1}{\text{poly}}$

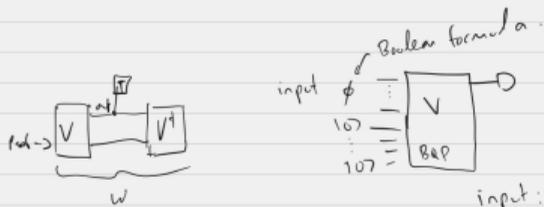
Output: Yes if \exists circuit V with $\leq k$ T gates
 s.t. $\exists \theta \in [0, 2\pi)$. $\|UV^\dagger - e^{i\theta}I\| < \epsilon$

No if \forall circuits V with $\leq k$ T gates
 and $\forall \theta \in [0, 2\pi)$. $\|UV^\dagger - e^{i\theta}I\| > 2\epsilon$

Stable is coQMA complete

Why are

s?



$$U|w\rangle|0\rangle \approx V|w\rangle|0\rangle$$

↑
acc. prob

parameter k .
 input: V_{in} , quantum verification circuit.
 eg. \exists circuit desc V with $\leq k$ gates.
 s.t. $\forall \phi \in \{0,1\}^n$ $\|V|\phi\rangle - |\psi\rangle\| \leq \frac{1}{\text{poly}}$.

Yes: $\exists x \forall (y) V$ accepts (x,y) w.p. $\geq \frac{2}{3}$
 No: $\forall x \exists (y) V$ " " " " $\leq \frac{1}{3}$



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Ok, so how can we build a better app?

- ▶ Need to render vector graphics
- ▶ Chrome uses Skia, so let's try that...

Stroke rendering is hard

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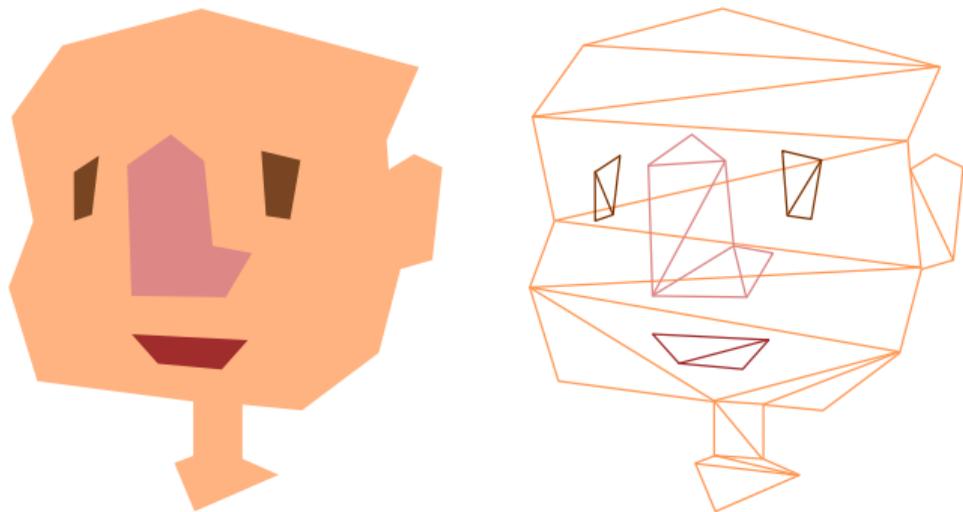
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Chrome vs. Inkscape:



But why?

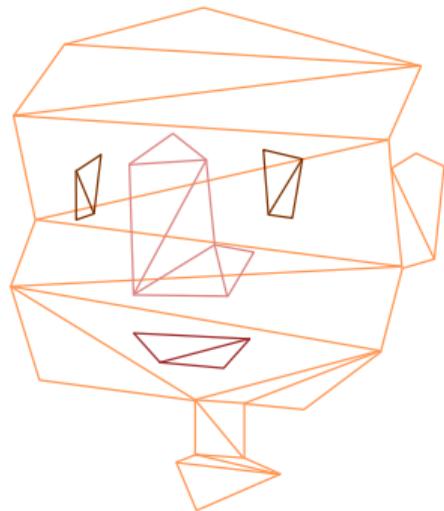
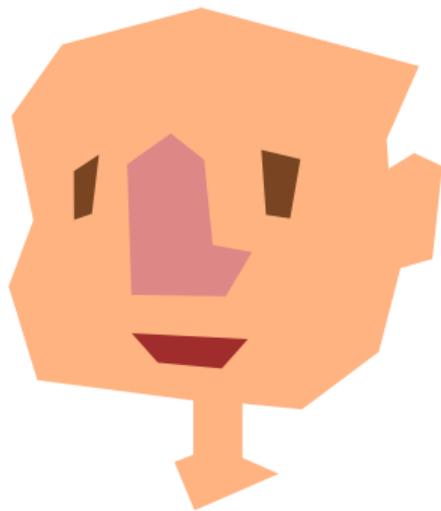
- ▶ Skia renders by tessellating 2D paths (turn into triangles)



Source: https://docs.rs/lyon_tessellation

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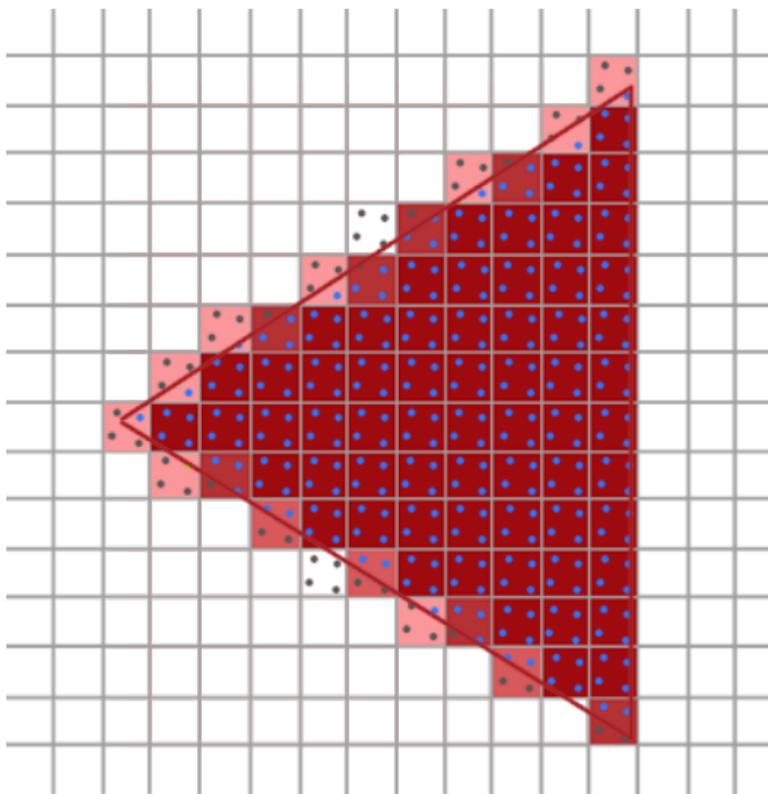
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- ▶ MSAA for anti-aliasing

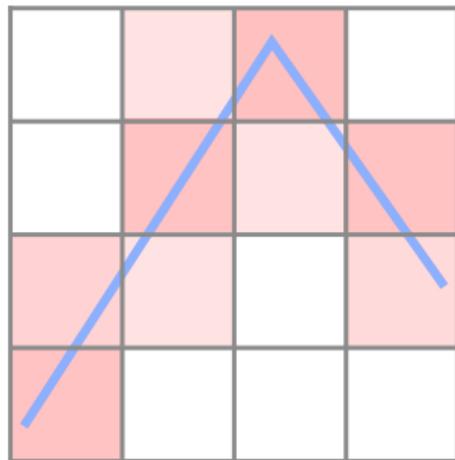
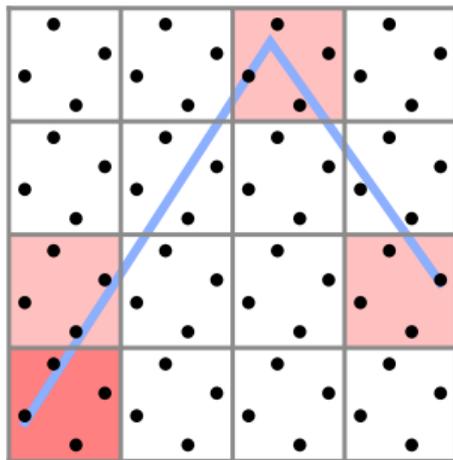


Source:

<https://learnopengl.com/Advanced-OpenGL/Anti-Aliasing>

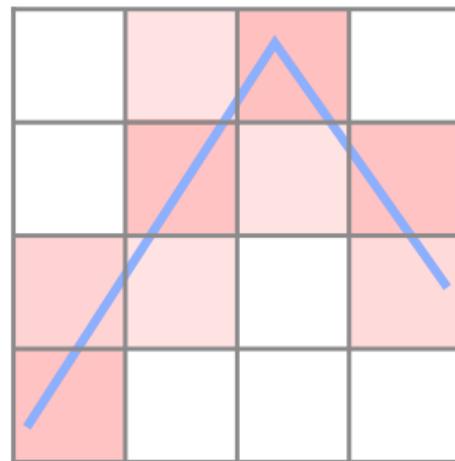
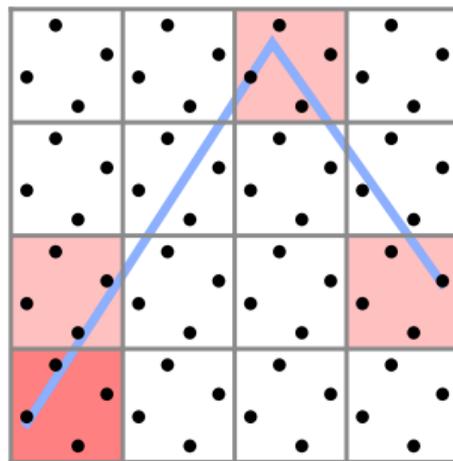
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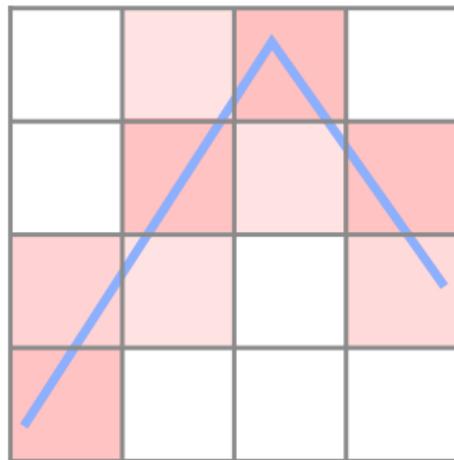
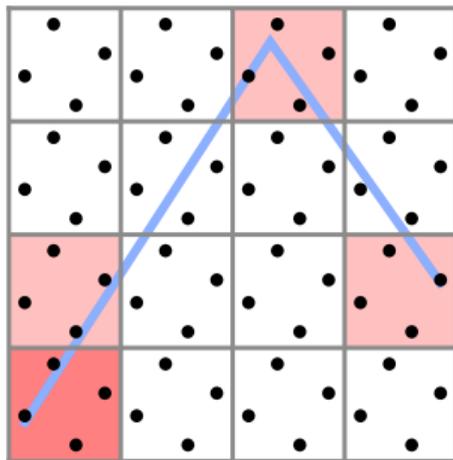
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- ▶ Difficult on GPU



Prior Work

- LP05 Charles Loop and Jim Blinn. 2005. Resolution independent curve rendering using programmable graphics hardware. *ACM Trans. Graph.* 24, 3 (July 2005), 1000–1009. <https://doi.org/10.1145/1073204.1073303>
- NH08 Diego Nehab and Hugues Hoppe. 2008. Random-access rendering of general vector graphics. *ACM Trans. Graph.* 27, 5, Article 135 (December 2008). <https://doi.org/10.1145/1409060.1409088>
- GLFN14 Francisco Ganacim, Rodolfo S. Lima, Luiz Henrique de Figueiredo, and Diego Nehab. 2014. Massively-parallel vector graphics. *ACM Trans. Graph.* 33, 6, Article 229 (November 2014). <https://w3.impa.br/~diego/projects/GanEtA114/>
- LHZ16 Rui Li, Qiming Hou, and Kun Zhou. 2016. Efficient GPU path rendering using scanline rasterization. *ACM Trans. Graph.* 35, 6, Article 228 (November 2016). <http://kunzhou.net/zjugaps/pathrendering/>

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How do the different rendering approaches compare?

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- ▶ How to deal with scene updates? (Not discussed much in the literature)

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- ▶ Your own ideas...

Skills

- ▶ Programming in a system programming language (probably Rust)
- ▶ GPU programming (probably wgpu/WebGPU) and rendering
- ▶ Read and understand scientific papers