

Your Title

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The Chinese University of Hong Kong

March 27, 2024





- 1 Cite and Footnote
- 2 Text, Lists, Tables and Figures
- 3 Columns, Code, Links and Footnote
- 4 Equations and Blocks
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Attention Is All You Need^[1]

^[1] Vaswani et al., “Attention is All you Need”, 2017.



Long Short-Term Memory^[2]

^[2] Hochreiter and Schmidhuber, “Long Short-Term Memory”, 1997.



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- Time-dependent Schrödinger's equation:

$$i\hbar \frac{\partial}{\partial t} |\Psi(t)\rangle = \hat{H} |\Psi(t)\rangle$$



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- Mathematically, a function $f(x)$ is linear iff $f(u + v) = f(u) + f(v)$ and $f(cu) = cf(u)$.



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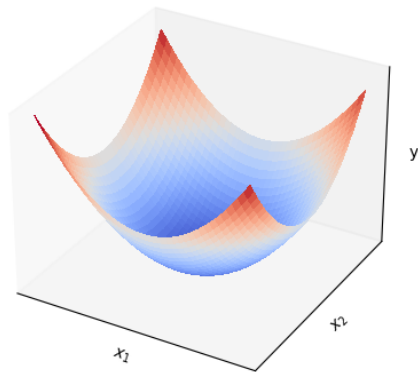


Figure 1: Convex Surface



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Index	Areas (m^2)	Rent (HKD)
1	40	134072
2	92	182241
3	37	134731
4	124	204325
5	88	187375
...



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Figure 2: Lenna



Algorithm 1 An algorithm with caption

Require: $n \geq 0$ **Ensure:** $y = x^n$ $y \leftarrow 1$ $X \leftarrow x$ $N \leftarrow n$ **while** $N \neq 0$ **do** **if** N is even **then** $X \leftarrow X \times X$ $N \leftarrow \frac{N}{2}$ **else if** N is odd **then** $y \leftarrow y \times X$ $N \leftarrow N - 1$ **end if****end while**

▷ This is a comment



- Beamer (LaTeX) - Wikipedia
- Please refer to page 2.
- [https://en.wikipedia.org/wiki/Beamer_\(LaTeX\)](https://en.wikipedia.org/wiki/Beamer_(LaTeX))



- **Beamer** is a \LaTeX document class for creating presentation slides, with a wide range of templates and a set of features for making slideshow effects. It supports pdf \LaTeX , \LaTeX + dvips, Lua \LaTeX and Xe \LaTeX . The name is taken from the German word “Beamer” as a pseudo-anglicism for “video projector”.¹

¹[https://en.wikipedia.org/wiki/Beamer_\(LaTeX\)](https://en.wikipedia.org/wiki/Beamer_(LaTeX))



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Example

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Theorem

$\mathbf{X}^T \mathbf{X}$ is invertible $\iff \mathbf{X}$ has linearly independent columns.



Theorem

$\mathbf{X}^T \mathbf{X}$ is invertible $\iff \mathbf{X}$ has linearly independent columns.

Proof.

Firstly, note that $\mathbf{X}^T \mathbf{X} \in \mathbf{R}^{n \times n}$. We denote $N(\mathbf{X})$ as the kernel (nullspace) of \mathbf{X} , and $R(\mathbf{X})$ as the range (column space) of \mathbf{X} . We prove $\mathbf{X}^T \mathbf{X}$ and \mathbf{X} share the same kernel such that once $N(\mathbf{X}) = 0$, $N(\mathbf{X}^T \mathbf{X}) = 0$ and vice versa. □



Proof.

1) Prove $N(\mathbf{X}) \subset N(\mathbf{X}^T \mathbf{X})$

$$\forall v \in N(\mathbf{X}), \mathbf{X}^T \mathbf{X} v = \mathbf{X}^T \mathbf{0} = \mathbf{0}$$

$$\implies v \in N(\mathbf{X}^T \mathbf{X}) \implies N(\mathbf{X}) \subset N(\mathbf{X}^T \mathbf{X}).$$



Proof.

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$$\implies v \in N(\mathbf{X}^T \mathbf{X}) \implies N(\mathbf{X}) \subset N(\mathbf{X}^T \mathbf{X}).$$

2) Prove $N(\mathbf{X}^T \mathbf{X}) \subset N(\mathbf{X})$

$$\forall v \neq \mathbf{0} \in N(\mathbf{X}^T \mathbf{X}), \mathbf{X}^T \mathbf{X}v = \mathbf{0} \implies v \in N(\mathbf{X}^T) \text{ or } \mathbf{X}v \in N(\mathbf{X}^T).$$

However, we have $R(\mathbf{X}) \perp N(\mathbf{X}^T)$ and $\mathbf{X}v \in R(\mathbf{X})$,

$$\implies \mathbf{X}v \perp N(\mathbf{X}^T) \implies \mathbf{X}v \notin N(\mathbf{X}^T) \implies v \in N(\mathbf{X}^T)$$

$$\implies N(\mathbf{X}^T \mathbf{X}) \subset N(\mathbf{X})$$



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$$1), 2) \implies N(\mathbf{X}^T \mathbf{X}) = N(\mathbf{X})$$





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- [2] Sepp Hochreiter and Jürgen Schmidhuber. “Long Short-Term Memory”. In: *Neural Computation* 9.8 (Nov. 1997), pp. 1735–1780. ISSN: 0899-7667.



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