

璀璨的星空 —— 美麗的语言世界 (II)

The Brilliant Starry Sky —— The Beautiful World of Language (II)



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預訓練前準備 (Pretraining Preparation)

1. 蒐集語料 (Data Collection)
2. 清理與整理資料 (Cleaning and Curation)

原始資料整理成約
13 兆 tokens

詞元化訓練

Tokenizer Training

詞元表徵 (token representation) :
[1.2, 0.5, 2.1, 0.5, -2.1...] 高達12,288 維

選擇約 3 兆 Tokens 進行
預訓練

初始值為 random
例如：春
[0.03, -0.01, 1.2, ...]

字彙表 (100,000 -250,000)

Vocabulary Table

Token-Index Mapping

Index	Token
0	the
1	dog
2	is
...	...

嵌入矩陣

Embedding Matrix

Embedding Layer

Index	Vector
0	[1.05, -0.72, ...]
1	[0.87, 1.35, ...]
2	[0.23, -1.10, ...]
...	...

預訓練方法

1. Self-Supervised Learning (自監督學習)

2. Teacher Forcing (老師強迫)

3. Causal Masking (因果遮罩)

如何學習/理解

4. Attention

+

5. FFN



[春][天][到][了][百][花][開][,][桃][花][紅][,][李][花][白][。](答
案：ground truth：春天到了，百花開，桃花紅，李花白。)

Causal Masking (因果遮罩)

[春][天][到][了]

State

由[了]的 state：預測下一個詞元 (Next Token Prediction)

[春][天][到][了][樹]

[春][天][到][了][樹]

Output Probabilities

Feed Forward Network (FFN)
(Attractor enhancement /suppression)

Self-Attention
(Semantic direction)

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Self-Attention
(Semantic direction)

Current Active State
Context-so-far representation

[春][天][到][了][

Token Embedding + Positional Embedding

Prompt / Previous Tokens

如何學習/理解

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[春][天][到][了][樹]

調整參數矩陣

Embedding Matrix

Embedding Layer

Index	Vector
0	[1.6, 2.3, 1.05, 0.7, ...]
1	[0.9, 1.6, 0.85, 1.5, ...]
2	[0.5, 3.6, 0.97, 2.3, ...]
...	...

降低：
樹 — 百 = Loss

最後預訓練完的
嵌入矩陣 / 參數

理解：Attention + FFN

Attention：注意力

Feed-Forward Neural Network (FFN)：前饋神經網路

Causal Masking：因果遮罩。每一個 token 只看前面與其之關係 (relationships)

Attention - 語意方向 (semantic direction)



FFN - 語意細化並鞏固 (semantic consolidation)

咖啡店因經營不善 [倒] 了。
因為地震房子 [倒] 了。
我每天定時 [倒] 垃圾。
他走路不小心，滑 [倒] 了。
他考試成績總是在 [倒] 數幾名。
開車最難的是 [倒] 車。

咖啡店因經營不善 [倒] 了
[1.2, 0.5, 2.1, 0.5, -2.1...]

因為地震房子 [倒] 了。
[2.4, 1.6, -3.2, 0.7, 1.5...]

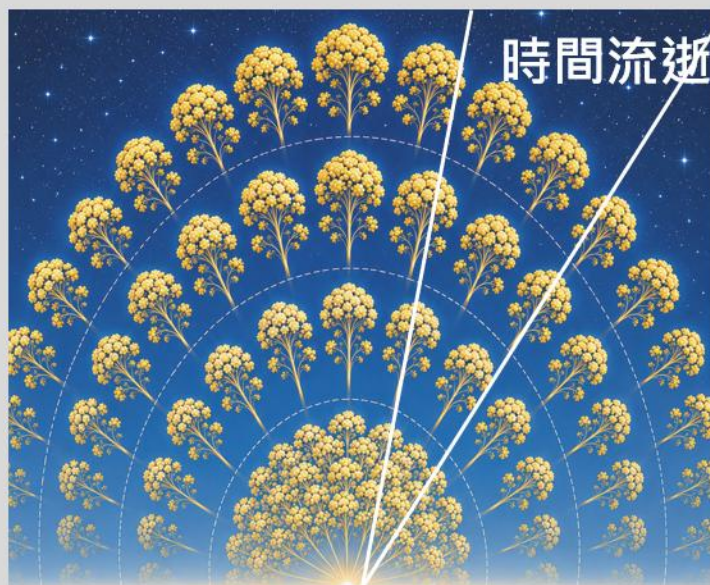


[倒]
[1.4, 0.7, 1.1, -0.5, 2.3...]

[倒]
[2.6, 2.6, -1.2, 0.5, 1.8...]

Attention

轉眼過了九年，我們要畢業了，[時間過得真快] 。
轉眼過了九年，我們要畢業了，[光陰似箭] 。
轉眼過了九年，我們要畢業了，[歲月如梭] 。
轉眼過了九年，我們要畢業了，[時光似白駒過隙] 。
轉眼過了九年，我們要畢業了，[倏忽九載] 。
轉眼過了九年，我們要畢業了，[時光似飛彈] 。



時間流逝(Passage of Time)

[光陰似箭]

[時間過得真快]

語意方向 (Semantic Direction)

時間流逝 (Passage of Time)

Parallel Basins

Time [時間]



passing [光陰似箭]



quickly [歲月如梭]



fleeting [時光似白駒過隙]

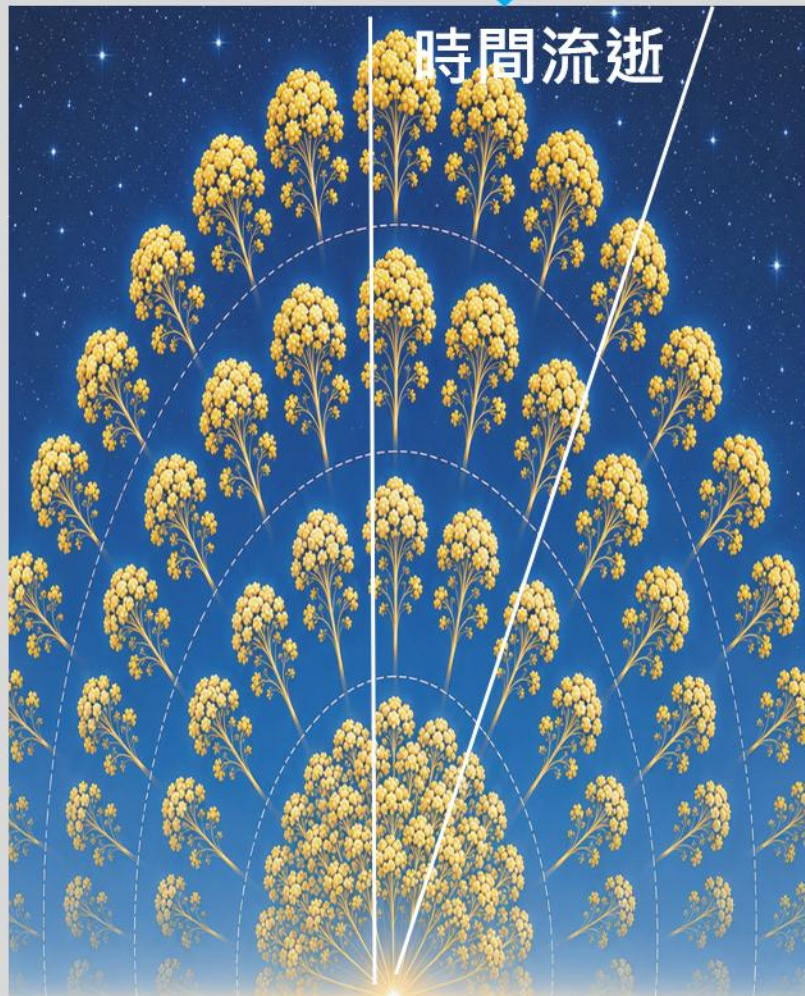


irreversible [時光似飛彈]

Attention :

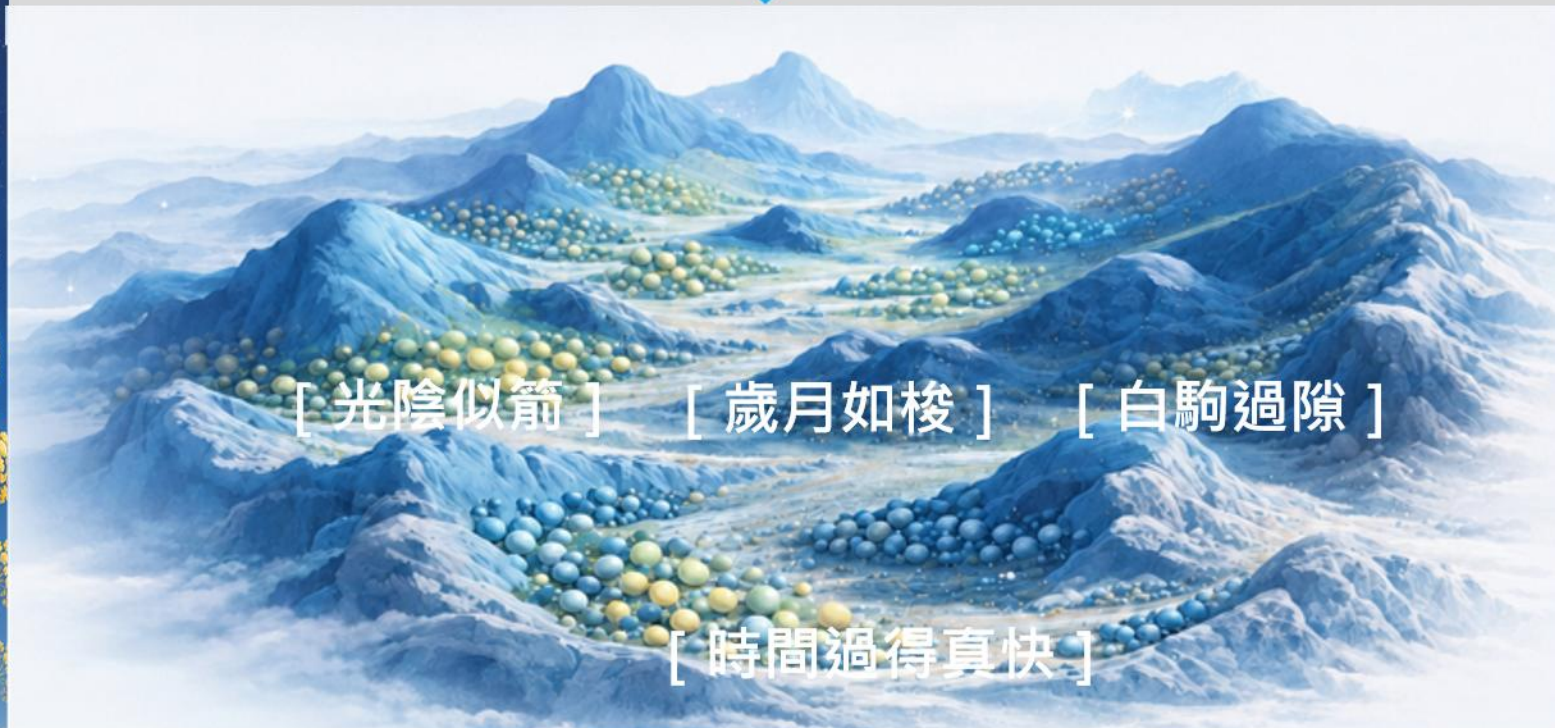
語意方向 (Semantic Direction)

時間流逝 (Passage of Time)



FFN :

語意細化並鞏固 (Semantic Consolidation)



預訓練前

字彙表 (100,000 - 250,000)

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Embedding Layer	
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預訓練後
嵌入矩陣

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Embedding Layer	
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[春][天][到][了][樹]

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調整參數矩陣 (嵌入矩陣)

Embedding Matrix

Embedding Layer

Index

Vector

0

[1.6, 2.3, 1.05, 0.7, ...]

1

[0.9, 1.6, 0.85, 1.5, ...]

2

[0.5, 3.6, 0.97, 2.3, ...]

...

...

降低：
樹 — 百 = Loss

最後預訓練完的
嵌入矩陣 / 參數

完成 預訓練

Attention :
語意方向 (Semantic Direction)
時間流逝 (Passage of Time)

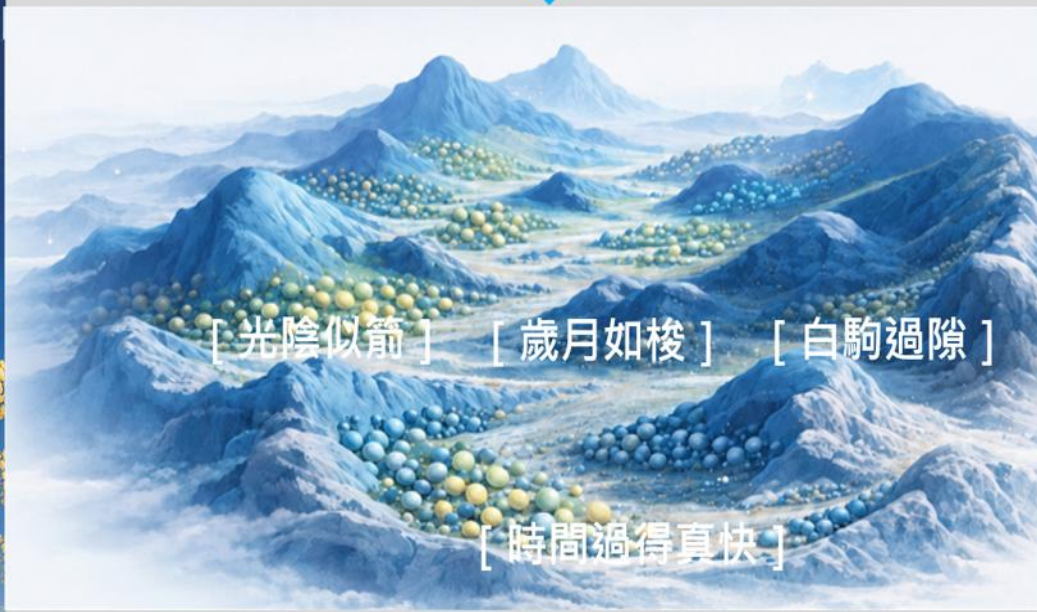
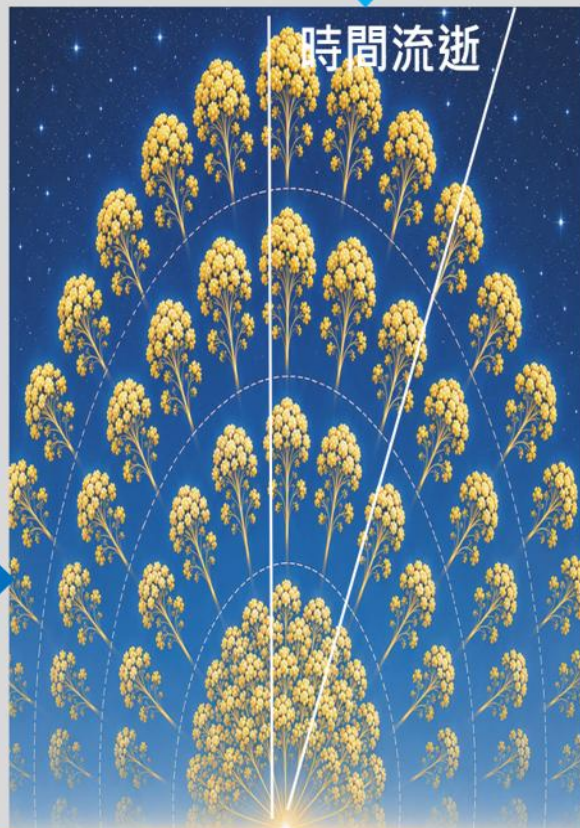


FFN :
語意細化並鞏固 (Semantic Consolidation)



Embedding Matrix

Embedding Layer	
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...	...



嵌入空間
Embedding Space

預訓練後的嵌入空間

Nested Basins

Engineering



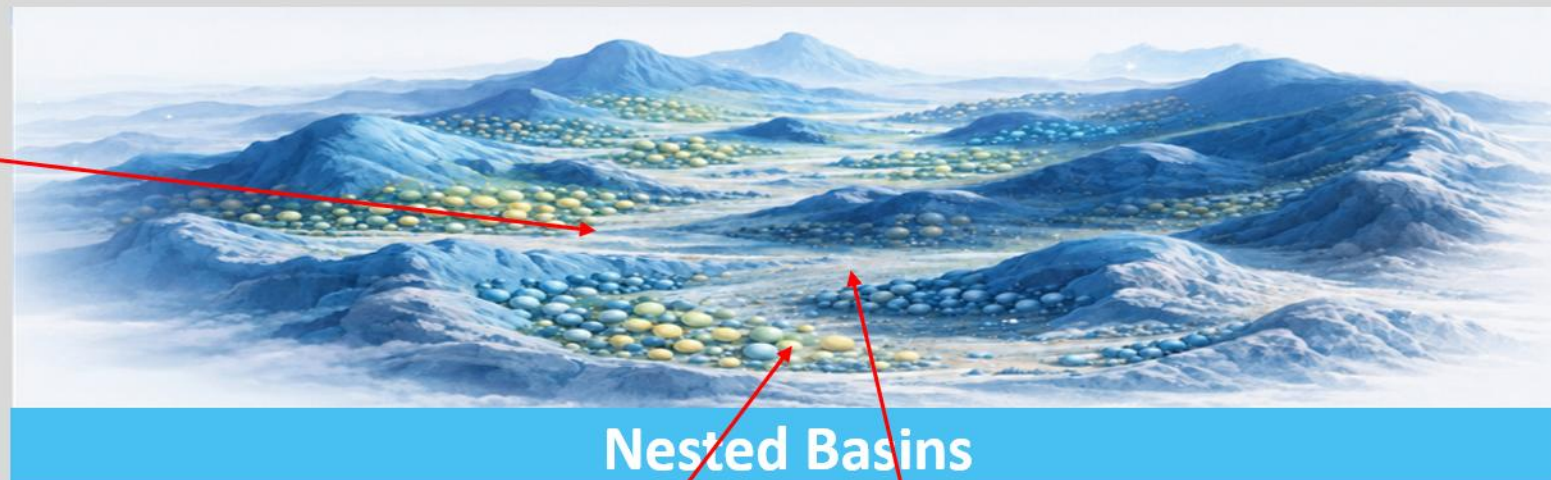
Aerospace



Propulsion



Aircraft Engine



Nested Basins



Parallel Basins

Aircraft Engine

- Compressor
- Combustor
- Turbine
- Nozzle
- Gearbox

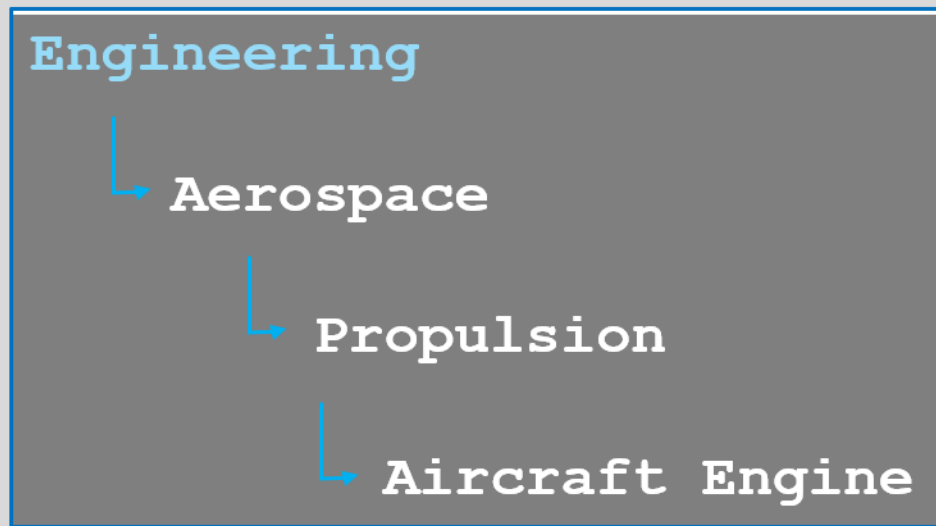
若再細化：

Parallel Basins

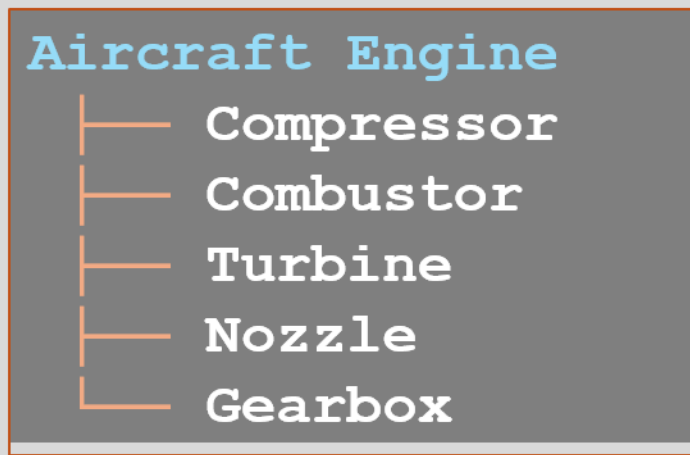
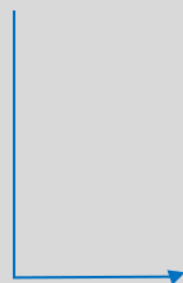
Turbine

- HPT
- LPT
- Cooling
- Aerodynamics
- Materials

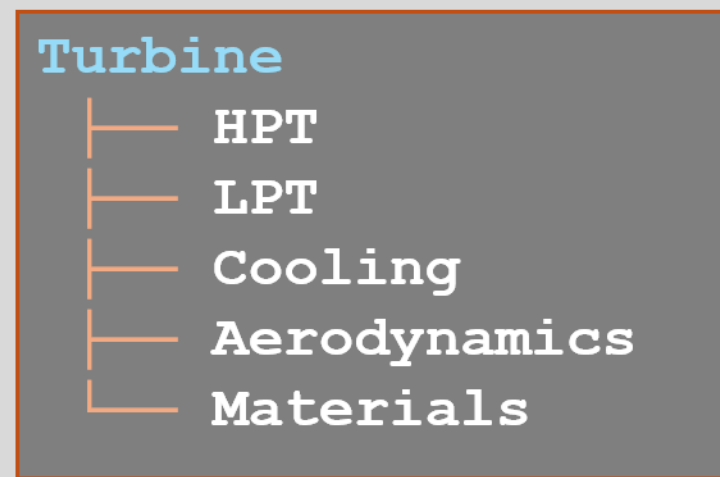
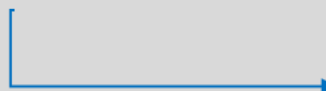
預訓練後的嵌入空間 → 分類大詞典

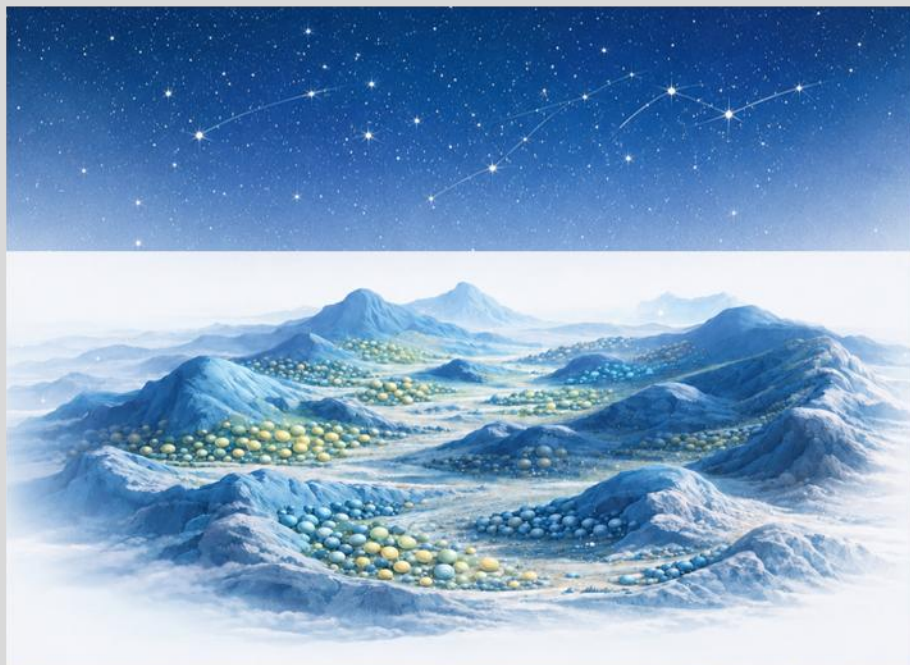


巢狀盆地
nested basins



平行盆地
parallel. basins





Inference Navigation in Cauliflower Sky

A greedy snake winds forward,
locally moving up and down (radius-wise)

推論如貪婪之蛇，蜿蜒向前，局部上下（半徑方向）移動

- **Radius (Terrain Specificity)**
How specialized / concrete the region is.
半徑（地形專門化程度）
區域語意的專門化 / 具體化程度。
- **Depth (Attractor Strength)**
How strong / stable the basin is.
深度（吸引強度）
盆地的吸引強度 / 穩定程度。
- **Trajectory (Inference Navigation)**
The path actually taken by the inference.
軌跡（推論導航）
推論在語意地形中實際行走的路徑。

- Every radius region has shallow and deep basins.
每一個半徑區域都包含深淺不同的盆地。
- A navigation may make radial excursions;
it need not be toward a higher region.
導地可進行半徑方向的往返，
不一定朝向更高專門化區域。
- A navigation can enter a deeper basin,
and it may simultaneously move outward
to a higher-specificity region.
導航可進入更深的盆地，
並可能同時往外移動到更高專門化區域。
- Forward progression with local
radial excursions.
向前推進，伴隨局部半徑方向的往返。



What did the engineer do?

[What] [did] [the] [engineer]
[do] ?

嵌入矩陣

Embedding Matrix

Embedding Layer	
Index	Vector
0	[1.6, 2.3, 1.05, 0.7, ...]
1	[0.9, 1.6, 0.85, 1.5, ...]
2	[0.5, 3.6, 0.97, 2.3, ...]
...	...

The engineer designed the turbine for the aircraft engine.

- [engine.]
- [aircraft]
- [the]
- [for]
- [turbine]
- [the]
- [designed]
- [engineer]
- [The]

• The
Output Probabilities

[do] State

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Current Active State
Context-so-far representation

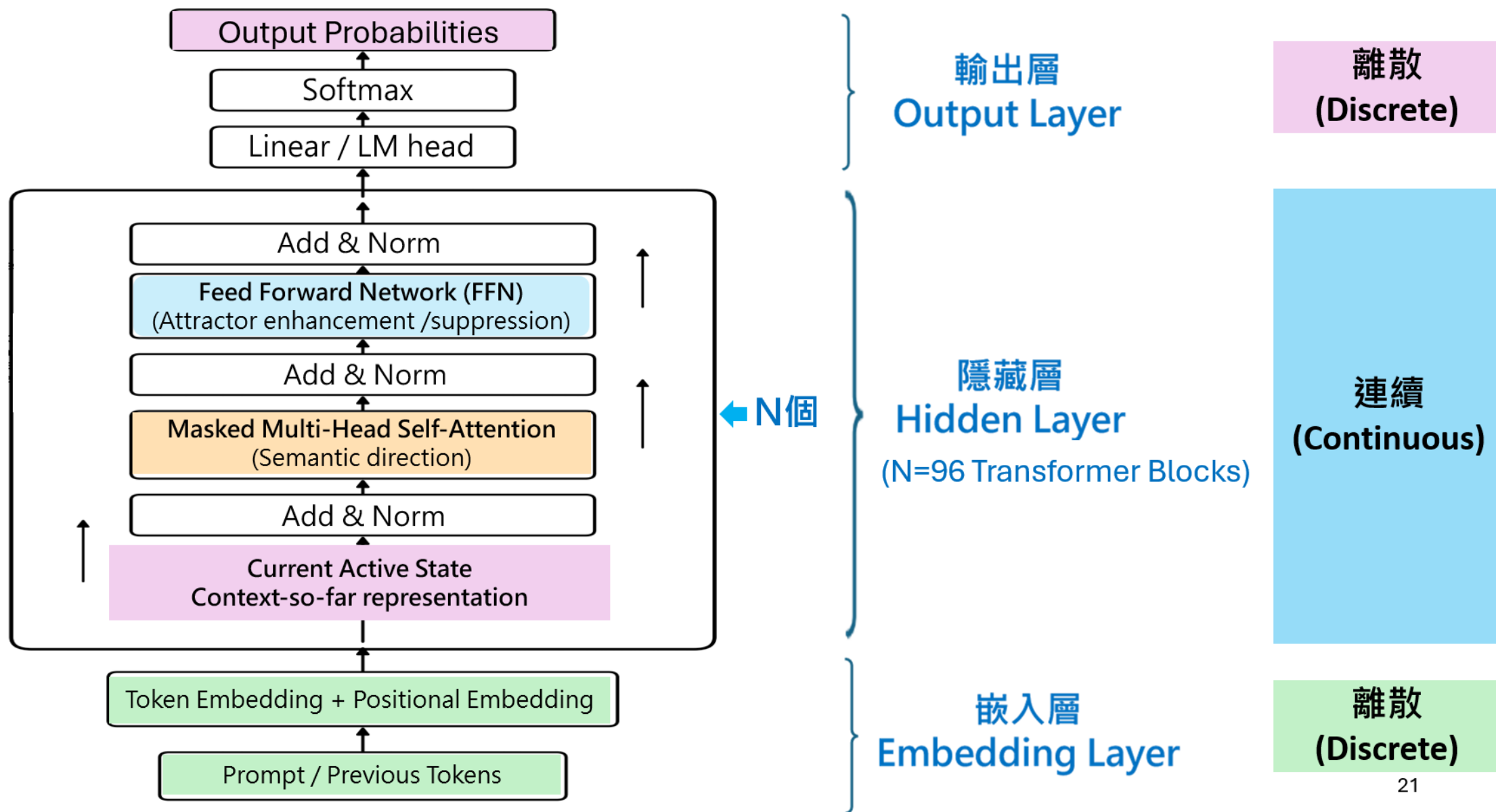
Token Embedding + Positional Embedding
Prompt / Previous Tokens

Current Active State



Decoder-only Transformer for ChatGPT-style Token Generation

ChatGPT 詞元生成的純解碼器 Transformer



Thank You

