International Council on Systems Engineering
A better world through a systems approach

PBSE Data Initialization Framework and Practice by Using LLM

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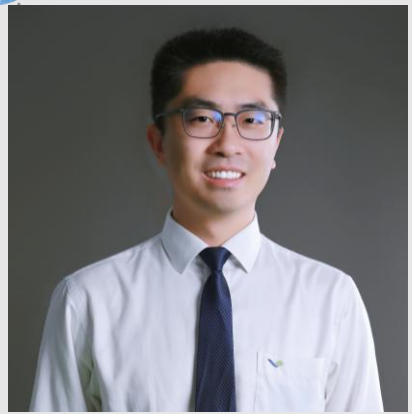


Degang Liang

Office Director, Senior engineer

Professional experience

Graduated from University of Southern California (USC), Serves as the head of systems engineering research and project application at COMAC, responsible for the COMAC Systems Engineering Manual and the training of systems engineers within the company. Long-term engagement in commercial aircraft products design, technical management, and project management.

Expertise

- Systems engineering management• AI4SE planning
- Agile systems engineering
- MBSE

Baoyu Dong

Engineer

Professional experience

Graduated from Nanjing University of Aeronautics and Astronautics, China, engages in research and project application at COMAC, long-term commitment to improving the company’s PLM platform architecture, particularly in data cleaning, analysis, and governance in the field of large language models.

Expertise

- PLM
- AI4SE

Today's Agenda

- Introduction
- Theory, Framework, and Platform development
- Case Study & Experiment Analysis
- Discussion & Conclusion

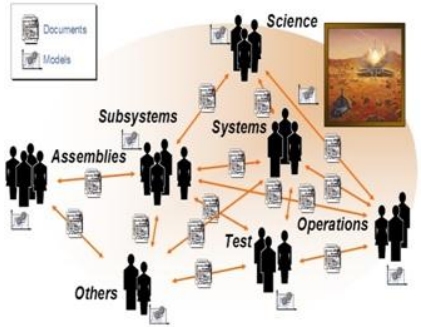
Introduction

1) DBSE/MBSE/PBSE Dilemma
2) LLMs Emerge

Dilemma

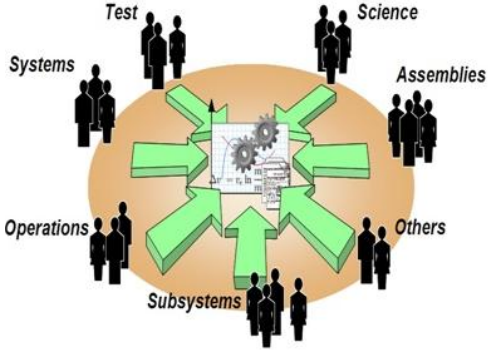
DBSE

- Expressiveness
- Looseness



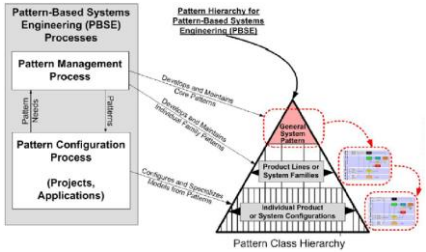
MBSE

- Usability
- Model complexity



PBSE

- Over-complexity
- Dependency
- Innovation limitation



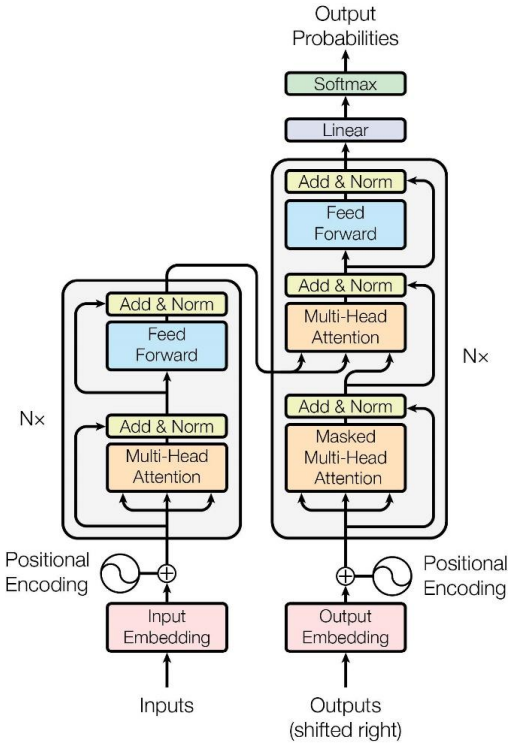
AI Infused

IBSE/AI4SE

- Empower SE
- Address cost overflow
- Identify "patterns"

LLMs

- Transformer (2017)
- ChatGPT (2022)

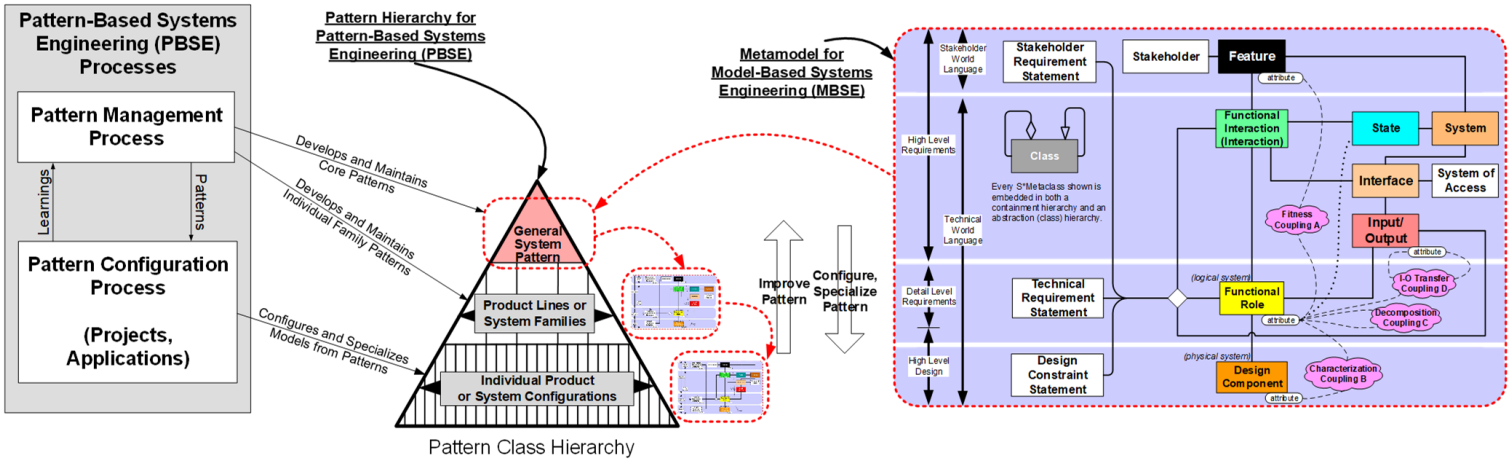


Theory, Framework, and Platform development

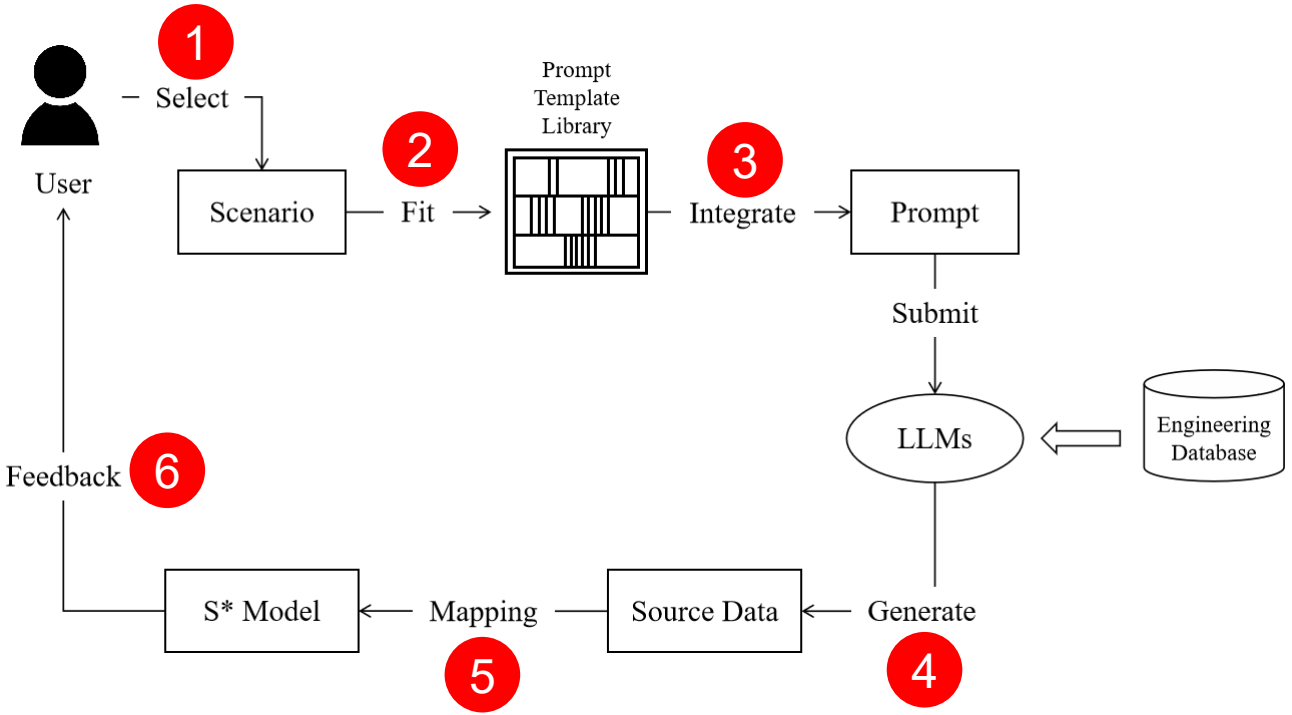
1) S* Metal-Model, S* Model, S* Pattern
2) Technical Framework
3) Platform Development

S* Metal-Model, S* Model, S* Pattern

Pattern-based Systems Engineering



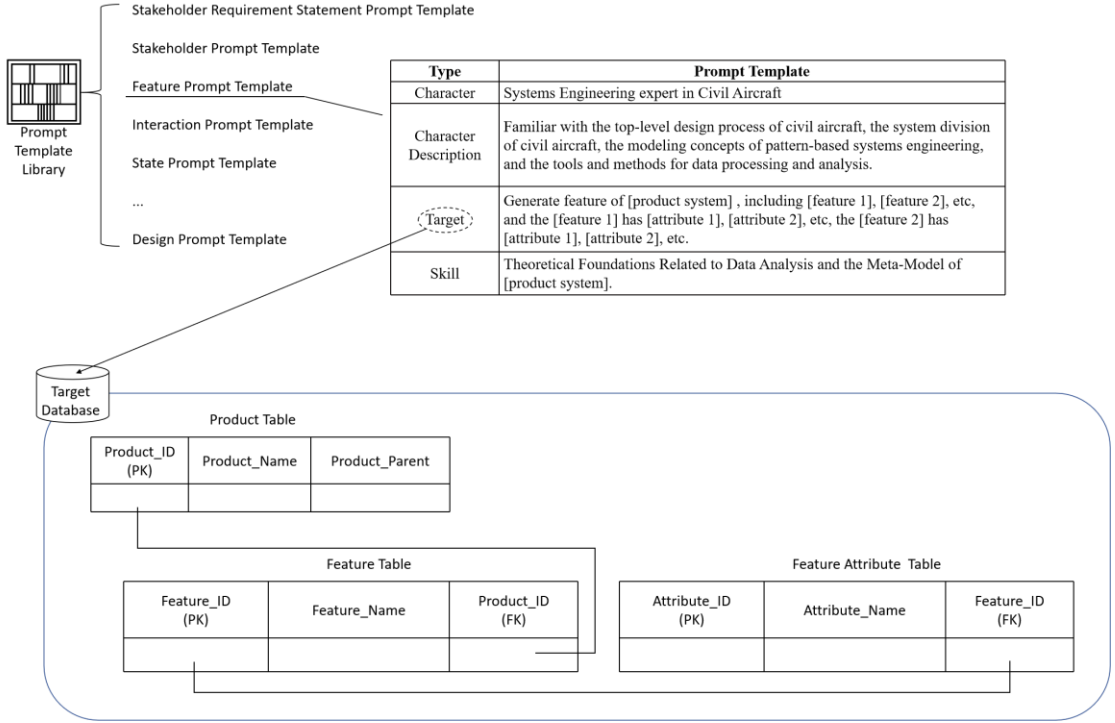
Technical Framework



1. Scenario Selection
2. Prompt Template Selection
3. Prompt Generation
4. LLM Response Generation
5. Mapping to Systematica Model
6. Feedback and Continuous Improvement

Platform Development

- Interface
- Database
- Library



Case Study & Experiment Analysis

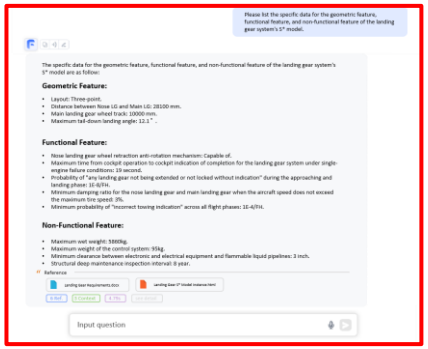
1) Case Study
2) Experiment Analysis

Case Study

	A	B	C
1	**Feature**	**Feature Attribute**	**Feature Attribute Value**
2	Geometry	Layout	
3		Distance between Nose LG and Main LG	
4		Main landing gear wheel track	
5		...	
6	Function	Nose landing gear wheel retraction anti-rotation mechanism	
7		Provide landing gear door open and closed status information.	
8		Maximum time from cockpit operation to cockpit indication of completion for the landing gear system under single-engine failure conditions.	
9		...	
10	Non-function	Maximum wet weight.	
11		Maximum weight of the control system.	
12		Minimum clearance between electronic and electrical equipment and flammable liquid pipelines.	
13		...	

Feature Table Architecting

LLM Interaction



	A	B	C
1	**Feature**	**Feature Attribute**	**Feature Attribute Value**
2	Geometry	Layout	Three-point
3		Distance between Nose LG and Main LG	28100 mm
4		Main landing gear wheel track	10000 mm
5		...	...
6	Function	Nose landing gear wheel retraction anti-rotation mechanism	Capable of
7		Provide landing gear door open and closed status information.	Capable of
8		Maximum time from cockpit operation to cockpit indication of completion for the landing gear system under single-engine failure conditions.	19 sec.
9		...	...
10	Non-function	Maximum wet weight.	5860kg
11		Maximum weight of the control system.	95kg
12		Minimum clearance between electronic and electrical equipment and flammable liquid pipelines.	3 in
13		...	...

Feature Table Initializing

Experiment Analysis

Feature	Feature Attribute	Feature Attribute Value	Amount	Chapter	Document ID.
Geometry	Layout	Three-point	8	3	XXXXX
	.....	.....		...	
Function	Nose landing gear wheel retraction anti-rotation mechanism	Capable of	12	4	
	.....	.....		...	
Non-function	Maximum wet weight	5860kg	22	5	
	.....	.....		....	

Mehtod 1

Raw Prompt without Engeering

Method 2

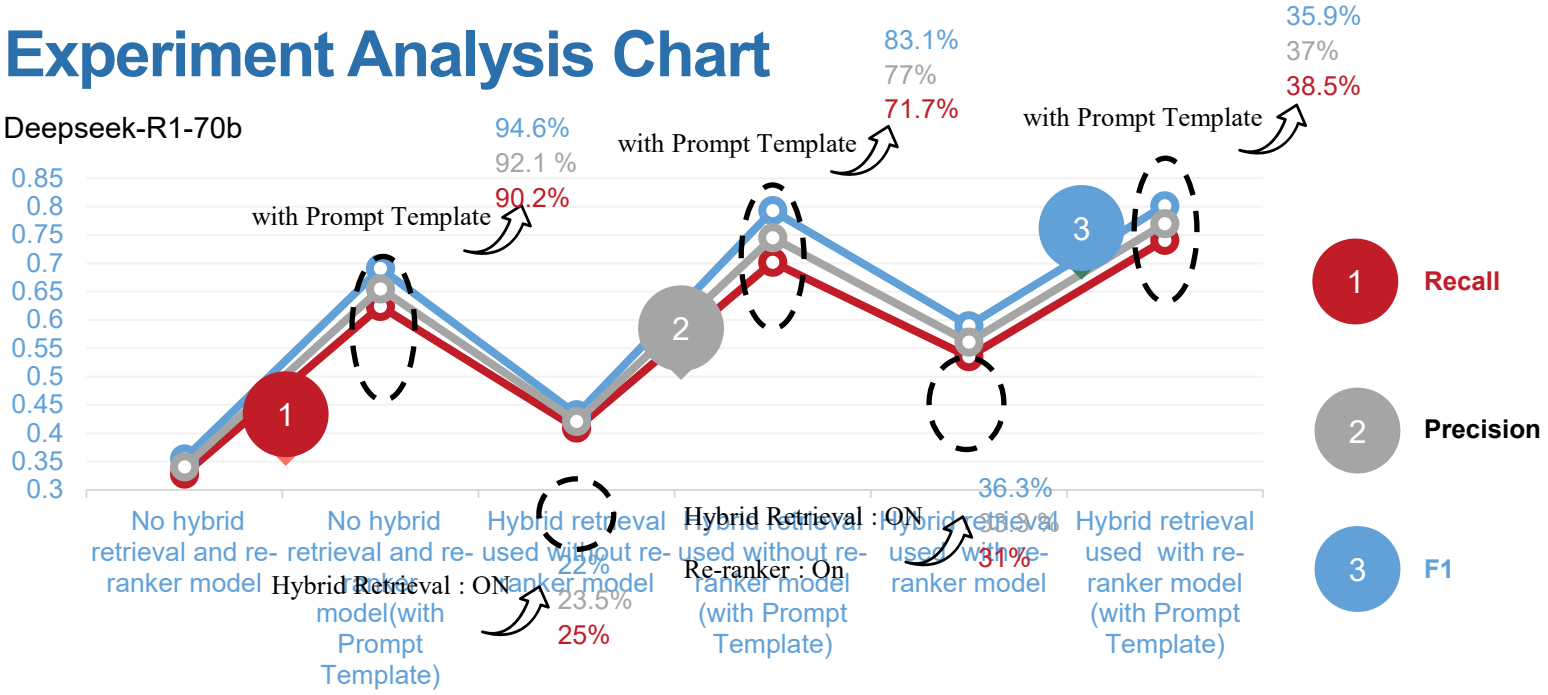
Prompt Template with Engeering

Experiment Analysis

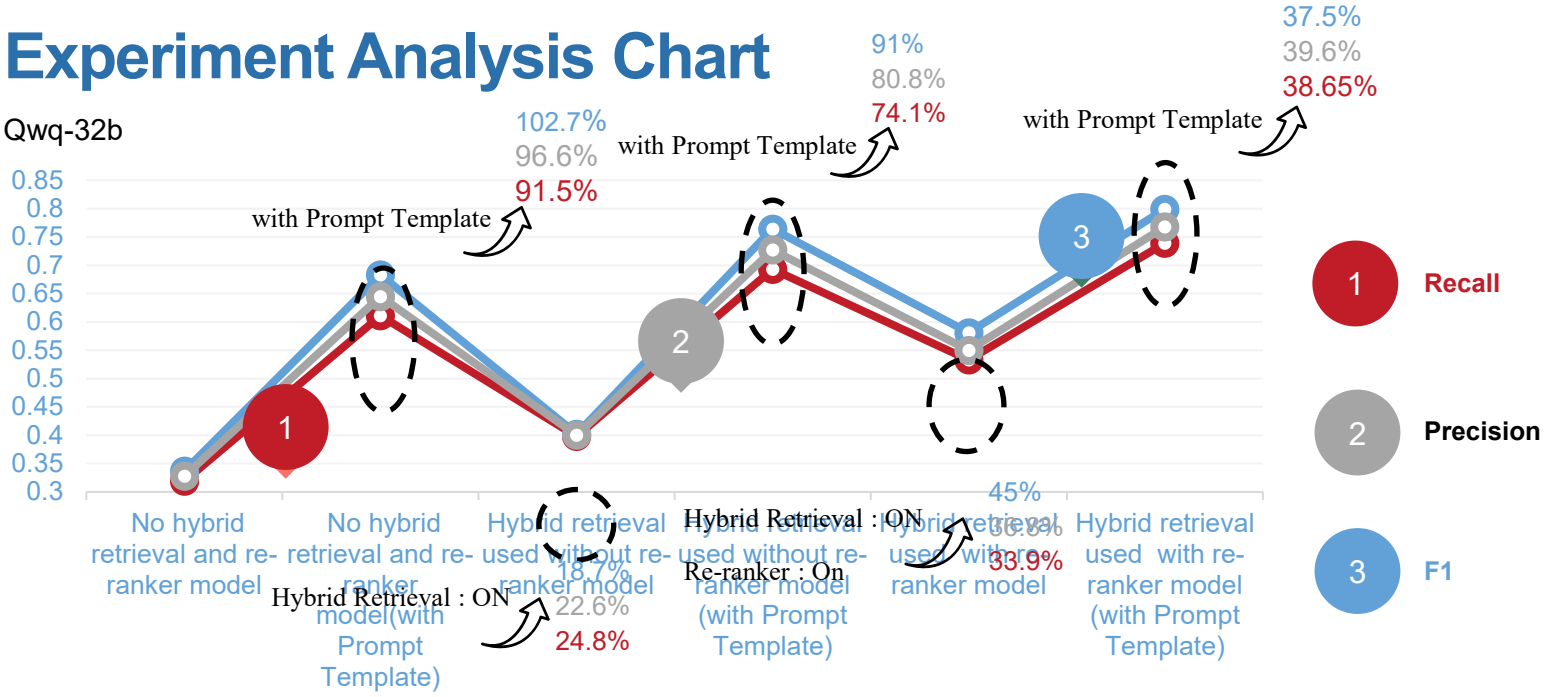
$$Recall = \frac{TP}{TP + FN} \qquad Precision = \frac{TP}{TP + FP} \qquad F1 = \frac{2 \times Precision \times Recall}{Precision + Recall}$$

	Methods	LLMs	Amount of Feature Attribute Value	Recall	Precision	F1
	Hybrid Retrieval = False Re-ranker = False					
No hybrid retrieval and re-ranker model	M1-LLM	Deepseek-R1-70b	9	0.328	0.355	0.341
		Qwq-32b		0.319	0.337	0.328
	LLM(with Prompt Template)	Deepseek-R1-70b	21	0.624	0.691	0.655
		Qwq-32b		0.611	0.683	0.645
	Hybrid Retrieval =True Re-ranker = False					
Hybrid retrieval used without re-ranker model	LLM	Deepseek-R1-70b	12	0.409	0.433	0.421
		Qwq-32b		0.398	0.402	0.400
	LLM(with Prompt Template)	Deepseek-R1-70b	27	0.702	0.793	0.745
		Qwq-32b		0.693	0.764	0.727
	Hybrid Retrieval = True Re-ranker = True					
Hybrid retrieval used with re-ranker model	LLM	Deepseek-R1-70b	17	0.535	0.590	0.561
		Qwq-32b		0.533	0.581	0.550
	LLM(with Prompt Template)	Deepseek-R1-70b	31	0.741	0.802	0.770
		Qwq-32b		0.739	0.799	0.768

Experiment Analysis Chart



Experiment Analysis Chart



Discussion & Conclusion

1) Discussion
2) Conclusion

Discussion

Remaining Issues:

- The integrity of data initialization is still lacking.
- Understanding regarding the same content expressed in different forms is lacking.
- The deployment of such systems in enterprises has certain thresholds.

Conclusion

- Address fundamental issues such as the complexity of constructing S* models.
- Reduc the barriers to entry and improved efficiency by leveraging PBSE data reuse.
- Contribute to increasing the success rate of enterprises in solving problems under different system engineering approaches.
- Partially solve the problem regarding the difficulty of capturing system environment requirements or assumptions during the development phase

Vision of Future:

- Generate higher quilty outputs by fune-tuning and information continously integating.
- Explore more senarios in SE domain.
- SE AI Agents.

35th Annual INCOSE international symposium

hybrid event

Thank You

Ottawa, Canada

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