

Should Novice People Use Smart Tools or Smart People Use Support Tools: The Role of AI in SE

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🔔 AI Will Replace Systems Engineers – Are You Ready? 🚨

Elon Musk recently made waves with his prediction that AI will make jobs optional, leading to... While this sounds utopian, it poses a real challenge for Systems Engineers among the others.

- 🔍 **Requirements Analysis:** AI can analyze vast data sets to identify requirements faster and Language Processing (NLP).
- 💡 **System Design:** AI-driven design tools create optimized system architectures, simulating time.
- 🔧 **Testing and Validation:** Automated AI testing frameworks perform extensive, rigorous testing reducing costs.
- 🔧 **Maintenance and Upgrades:** Predictive maintenance algorithms forecast failures and maintain minimal downtime.

The transition is already happening, with companies adopting AI tools to enhance efficiency. systems engineers must adapt to a new role focused on oversight and strategic decision-making. Musk's vision might seem dystopian, but it raises important questions about the future of work. To approach this AI-dominated era, the engineering community must innovate and find new ways to add value.

Are you ready for this shift? How are you preparing for an AI-driven future?

https://www.linkedin.com/posts/pierfeliceciancia_ai-systemsengineering-mbse-activity-7201577964214353920-3dJm/

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**AI will replace
(Systems)
Engineers**



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Outline



- **Artificial Intelligence (AI)** – what is it, and how do I know
- How do we use AI at TAU-SERI
- Untold (bad) Consequences
- Conclusions

Takeaway

- AI is (just) a computational technology
 - Garbage In Garbage Out
 - Huge environmental footprint and other disadvantages
- Use with care – be smart!

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When & What is AI?

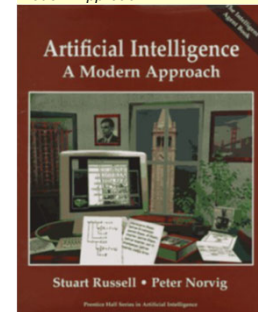
- The “inception” of AI – Dartmouth workshop, 1956
 - Marvin Minsky, John McCarthy, Claude Shannon, Nathan Rochester, Ray Solomonoff, Oliver Selfridge, Trenchard More, Arthur Samuel, Allen Newell, Herbert A. Simon, Julian Bigelow, Ross Ashby, W.S. McCulloch, Abraham Robinson, David Sayre, and Kenneth R. Shoulders.
- “Two researchers from Carnegie Tech, Allen Newell and Herbert Simon, rather stole the show. ... Newell and Simon already had a reasoning program, the Logic Theorist (LT), about which Simon claimed, ‘We have invented a computer program capable of thinking non-numerically, and thereby solved the venerable mind-body problem.’ (Russell & Norvig, 1995)”
- AI is problem-solving, problem-solving is search
 - “The picture of problem-solving that had arisen during the first decade of AI research was of a general-purpose search mechanism trying to string together elementary reasoning steps to find complete solutions.”



1956 Dartmouth Conference:
The Founding Fathers of AI



Russell, S. J., & Norvig, P. (1995). *Artificial Intelligence: A Modern Approach*. Prentice-Hall.



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Yoram Reich Personal Journey

- Got interested in AI in 1984, when thinking about PhD studies
- Carnegie Mellon University, Steven Fennes, Alen Newell, Herbert Simon
- Participated in Newell's Soar Project
- PhD 1991: “Building and Improving Design Systems: A Machine Learning Approach”
- Courses at TAU
 - AI in engineering (~2000-2006)
 - ML in engineering (~2000-2006)
- Last ML contribution: a system for feature discovery and rule learning (2011-2013) – PhD, Dr. Ofer Dor
- Recent use of AI in 2023 in requirement acquisition (Peer et al., 2024)
- Following ChatGPT, using AI for scientific editorial work, research, and other tasks



Peer, J., Mordecai, Y., & Reich, Y. (2024, March). NLP4ReF: Requirements Classification and Forecasting: From Model-Based Design to Large Language Models. In *2024 IEEE Aerospace Conference* (pp. 1-16). IEEE.

Reich, Y. (1991). *Building and improving design systems: a machine learning approach*. PhD Thesis, Carnegie Mellon University.

Dor, O., & Reich, Y. (2012). Strengthening learning algorithms by feature discovery. *Information Sciences*, 189, 176-190.

Dor, O., & Reich, Y. (2013). Enhancing learning algorithms to support data with short sequence features by automated feature discovery. *Knowledge-Based Systems*, 52, 114-132.

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How Does AI Work? – A Rough Model

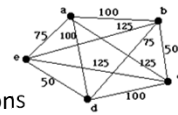


- AI tasks
 - Formulate a goal
 - Formulate the problem as a search space: which actions and states to consider
 - Search to reach the goal in the most effective way (least search cost, least execution cost)
- To be considered AI, the search space should be too large to traverse completely.

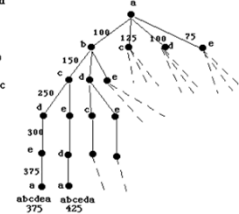
- Robot

- Goal to reach a location
- Search space: states – locations; actions – moves between locations
- Search: find the best way to move from present to goal location

An Instance of the
Traveling Salesman Problem



Search Space



- Deep learning (e.g., for foundation models, AI transformers)

- Goal to represent (structured, sequential, etc.) data with minimal errors
- Search space: states – a possible assignment of NN weights
- Search: find the most efficient way to assign weights to reach the goal



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TAU-SERI Examples



- AI for knowledge acquisition (RepGrid – Dos-based!) – Liron Shimshilashvili
- AI for requirement elicitation (NLP4ReF) – Jordan Peer, Yaniv Mordecai
- AI for everything – Shlomi Efrati
- AI for value estimation – Emilia Lavi
- AI for OPM diagram creation and verification – Daniel Aron
- AI for ad-hoc integration of systems – Tzvika Kaminsky




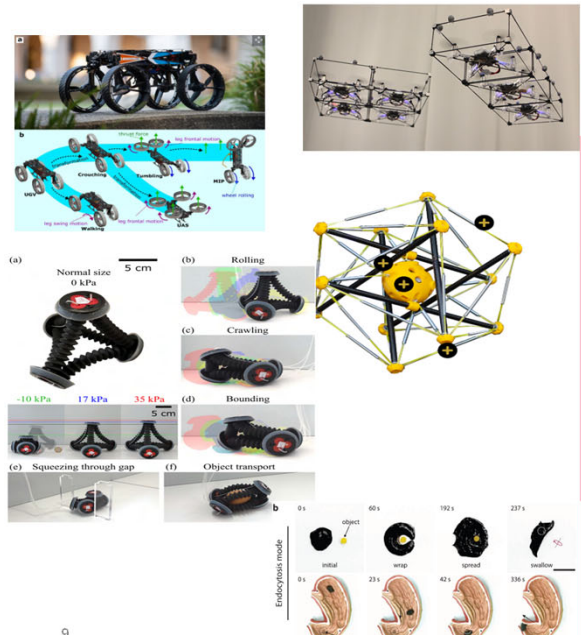
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AI for Knowledge Acquisition (RepGrid) – Liron Shimshilashvili





(a) Normal size 0 kPa, 5 cm scale

(b) Rolling

(c) Crawling

(d) Bounding

(e) Squeezing through gap

(f) Object transport

Embryonic mode: 0s (initial), 23s (wrap), 60s (spread), 192s (spread), 237s (spread), 336s (swallow)

Focus Cluster fluid architecture [Interior] "demonstrate the examples of thesis"

Crossplot fluid architecture "demonstrate the examples of thesis"

many degrees of freedom

few degrees of freedom


topology doesn't change

topology changes much

- Morphing matter •
- Drone Reconfigurable • Modquad
- spider Morphobot
- Coupled modeling PTERO
- Tetraflex
- jellyfish
- Slime Robot
- HEXACOPTER DRONE
- Squishy Robotics
- Spherical Movable
- Spikebot
- Myriad Robot • multi fingered
- jellyfish
- Morphing matter
- Slime Robot

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AI for Requirement Elicitation (NLP4ReF) – Jordan Peer (MSc thesis), Yaniv Mordecai (co-advisor)



[Ibid] [Domain] NLP4ReF-GPT System(NLP4ReF-GPT System)]

«centralBuffer»
NLP4ReF
[Initial or Newly Generated Requirements]

Input of Requirements to the Tool

Designing According to the Requirements

Output of Unforeseen Generated Requirements

NLP4ReF

Output Clean Answer

Module Input Question

Interface Module

GPT Answer

Insert data Function 2

Create a New File 2

Output : Delta List File Path

Input : New Generated Requirements

Peer, J., Mordecai, Y., and Reich, Y., "NL and Forecasting: From Model-Based Design to Big Sky: IEEE Aerospace Conference 2020" Peer, J., Mordecai, Y., and Reich, Y., "Gen submitted."

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AI for Everything – Shlomi Efrati (PhD thesis)



- Any challenge is an opportunity to engage with AI
- Summarize papers
- Improve, and rephrase text
- Compare approaches (advantages and disadvantages)
- Retrieve sources
 - Drill down to details:
 - From identifying a rival approach
 - To guide in its implementation to compare performance (which code, which steps, what IO)
- Do not give up getting an answer
- Rephrase, restart, and challenge the bot

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AI for Value Estimation – Emilia Lavi (PhD thesis)



- The value estimation process (using ChatGPT4o):
 - Introduce the generative AI tool with the value model
 - Give data (if this step is jumped over, you don't know whether the tool uses relevant and up-to-date information)
 - Be scrupulous when defining the stakeholders and the context
 - Ask the correct question
 - If the results are not logical, ask more questions
 - Ask easy questions first, to test the validity of the results

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ChatGPT4o Analyzes System Value – Emilia Lavi (PhD thesis)



- Case study #1 - **Concorde**
 - Applause
 - Overall correct evaluation, similar to expert-analyzed results
 - Superficial analysis for some value aspects, ignoring crucial data
- Case study #2 - **Selina**
 - Huge disappointment
 - The tool had no data, performed generic analysis, and got generic optimistic results unaligned with real-life and human analysis

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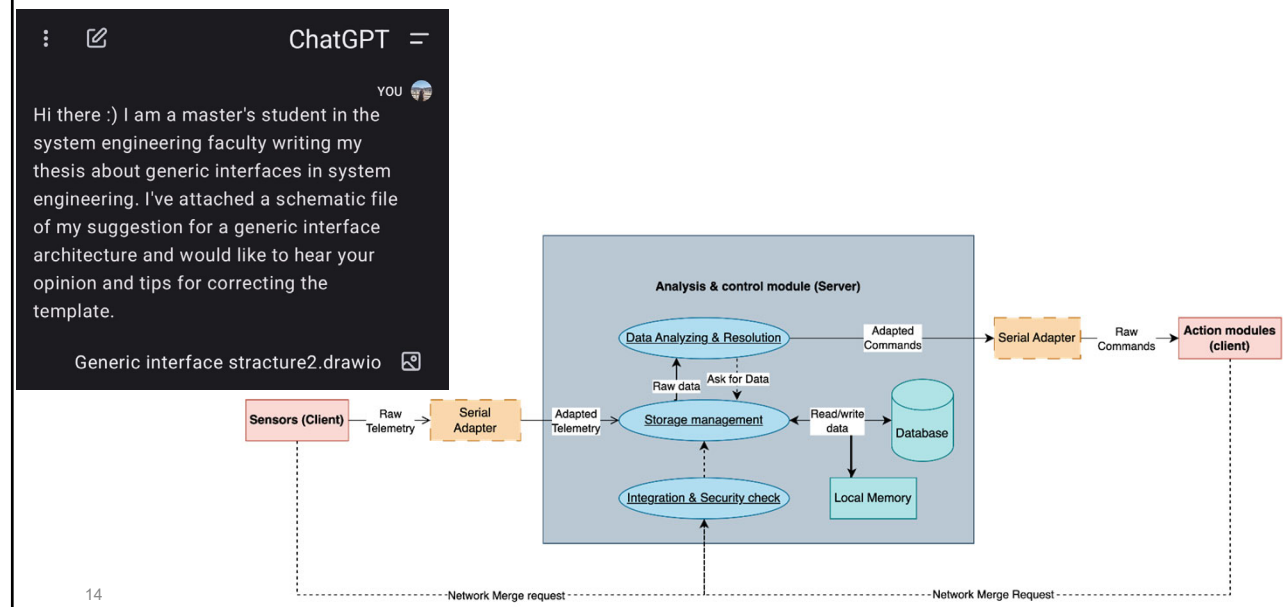
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AI for MB Diagram Creation and Verification – Daniel Aron (MSc thesis)

ChatGPT4o



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AI for MB Diagram Creation and Verification – Daniel Aron (MSc thesis)



Your schematic for a generic interface architecture in system engineering provides a clear depiction of data flow between sensors, the analysis and control module (server), and action modules. Here are some thoughts and suggestions for improving or refining your template:

1. Labeling and Clarity:

- Ensure all components are clearly labeled. For instance, specify the types of sensors and action modules, if possible, to provide more context.
- Add descriptions or annotations to explain each component's role briefly.

2. Data Flow and Interfaces:

- Highlight the types of data being transferred at each stage (e.g., telemetry data, commands).
- Clarify the role of the serial adapter and the specific protocols used for communication between sensors/action modules and the server.

3. Security and Integration:

- The "Integration & Security check" module is crucial. Detail the specific security measures and integration processes used. For example, mention encryption methods, authentication processes, and data validation techniques.
- Consider adding a feedback loop from the "Integration & Security check" to the sensors and action modules to indicate potential reconfiguration or security alerts.

4. Data Storage and Management:

- Explain the interaction between the "Storage management" module, the database, and local memory. Specify the data storage methods (e.g., SQL/NoSQL databases) and any

2024

- Detail how data integrity and consistency are maintained during read/write operations.

5. Scalability and Flexibility:

- Highlight how the architecture can scale with an increasing number of sensors and action modules.
- Discuss the flexibility of the interface in accommodating different types of sensors and actuators.

6. Adaptation and Resolution:

- Provide more details on the "Data Analyzing & Resolution" process. What algorithms or methods are used for data analysis? How are commands adapted and optimized for the action modules?

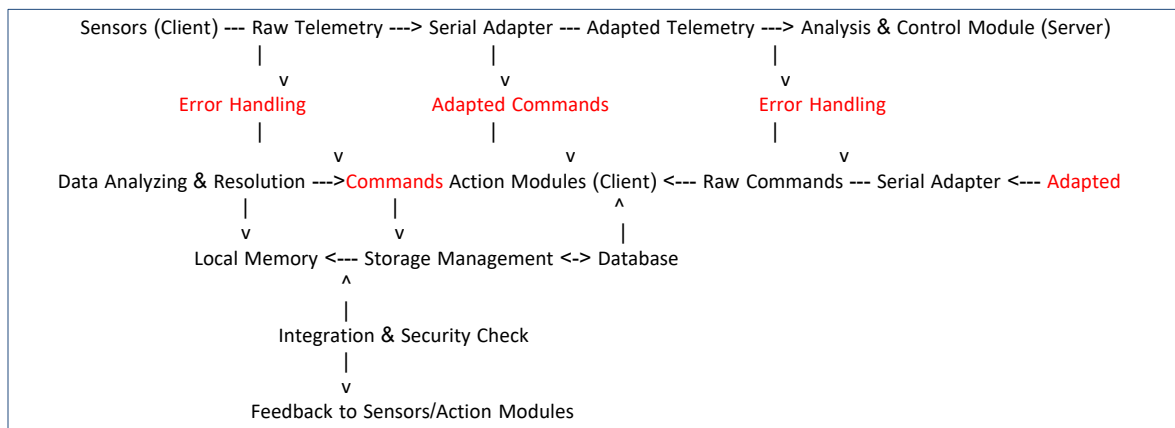
7. Modularity and Extensibility:

- Emphasize the modular nature of the architecture, allowing for easy integration of new sensors, action modules, or analysis components.
- Discuss potential extension points where new functionality can be added without disrupting the existing system.

8. Error Handling and Fault Tolerance:

- Add components or mechanisms for error detection, handling, and recovery to ensure system robustness and reliability.
- Consider how the system handles communication failures, data corruption, or other faults.

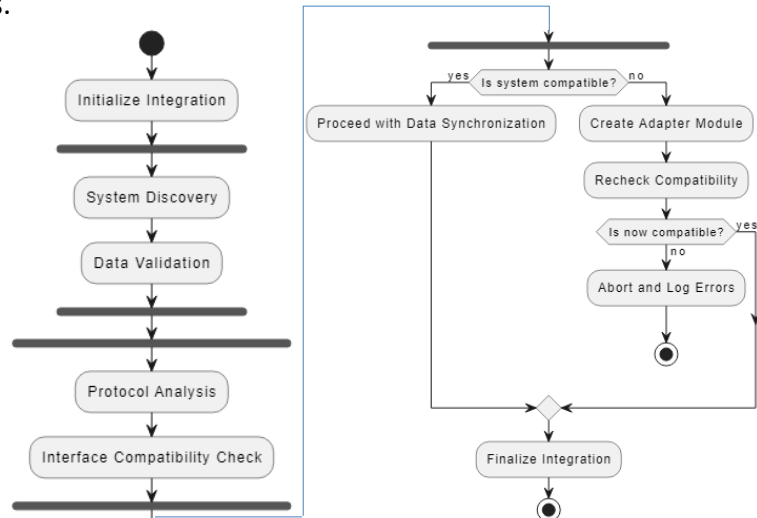
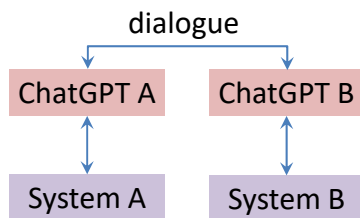
AI for MB Diagram Creation and Verification – Daniel Aron (MSc thesis)



AI for Ad-Hoc Integration of Systems – Tzvika Kaminsky (MSc thesis)



- Ad-hoc integration: combining systems or components as needed, without long-term planning, built-in interfaces, or structuring, often to address immediate business or operational needs.



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What is Untold?

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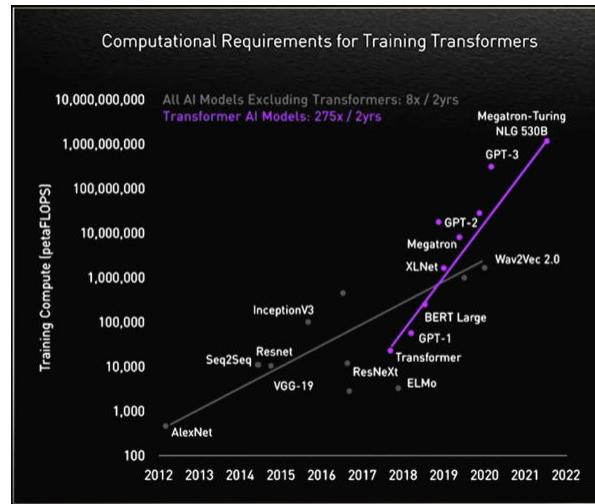
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Environmental Footprint of GenAI



- Energy Consumption of GenAI
 - “Building foundation models is often highly resource-intensive, ... costing hundreds of millions of dollars to pay for the underlying data and compute required. In contrast, adapting an existing foundation model for a specific use case or using it directly is much less expensive.” Wikipedia
 - Word done to reduce computational cost, but it does not defeat the exponential growth
 - Proposal to use GenAI to address the issues created by GenAI is interesting (PRP) ...
- Unclear how we handle the increased hardware needs
 - To manufacture
 - After upgrade
 - To run data centers [The energy needed to support data storage is expected to double by 2026. (Calvert, 2024).

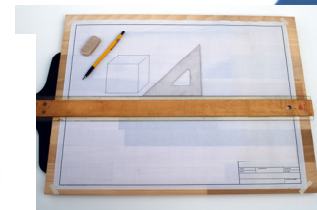
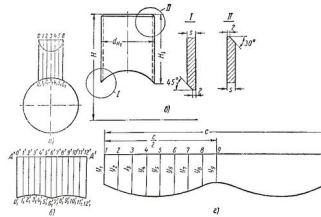


<https://blogs.nvidia.com/blog/what-is-a-transformer-model/>
 Calvert, B., AI already uses as much energy as a small country. It's only the beginning.
<https://www.vox.com/climate/2024/3/28/24111721/ai-uses-a-lot-of-energy-experts-expect-it-to-double-in-just-a-few-years> Mar 28, 2024



Human Skill Deterioration

- CAD – we no longer know how to draw 3D objects
- Waze – we no longer know how to navigate or where we are
- AI?



Swtpc6800 en>User:Swtpc6800 Michael Holley, Public domain, via Wikimedia Commons

<https://ru.pinterest.com/pin/438819557440109883/>
<https://www.mako.co.il/nexter-news/Article-cbea0232c981d81027.htm>

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New Failure Modes



- Added complexity may lead to emergent failure
- Three key challenges for the systems engineering of intelligent systems (SEBoK, AI):
 1. New failure modes not previously experienced in the engineering of systems.
 2. The unpredictability of performance due to non-deterministic and evolving behavior.
 3. Lack of trust and robustness in future systems performance.

https://sebokwiki.org/wiki/Artificial_Intelligence, V. 2.10, 6.5.24

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What We Learned



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Smart People Use AI as Support Tools



1. Use cleverly: know the theoretical underpinning to use it better
2. Be critical, you are the expert
3. Experience (in using tools) matters – we have to be smart in using them (see 1)
4. Learn to focus, select, and learn – pace too fast to follow everything
5. If AI does not do what you want, push it further!

- ... when you walk out, think that maybe I am an avatar using GenAI ...

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