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Promoting Sustainable Use of LLMs Through Mindful Prompting and Gamification

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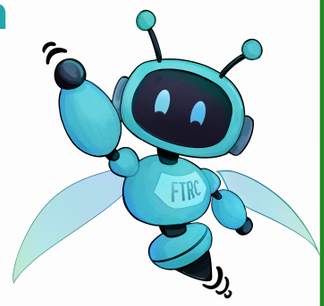


S-SPARC

Sustainable Smart Personal Assistant for Responsible Consumption

Green gateway chatbot designed to mitigate environmental costs of AI-driven code generation

Introduction & Aim

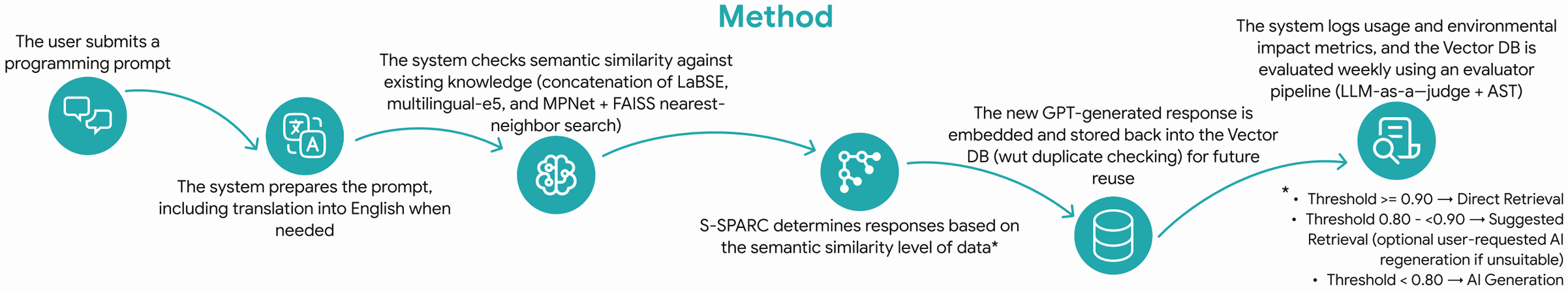
The Environmental Crisis
A single LLM prompt emits 4x more CO_2 than a google search, leading to significant digital pollution in educational settings.

The Solution
By integrating Technical RAG Optimization and Behavioral Interventions, S-SPARC filters and optimizes user interactions before they reach power-intensive generative models.

Research Objective
This study evaluate S-SPARC's use of Dynamic Gamified Incentives to drastically reduce AI's carbon footprint while maintaining rigorous academic productivity and pedagogical standards.

Experimental setup
A one-group pre-post quasi-experiment was conducted involving 60 informatics students in a Machine Learning course. The study utilized 100% S-SPARC environment to evaluate changes in sustainability awareness, LLM usage behavior, and platform perception.

Method



Usage Policies
Minimum prompt lengths and a 1-minute rate limit to prevent "lazy prompting" and promote critical thinking.

Dynamic Threshold Gamification
Points are deducted proportionally for excessive usage

$$\text{Points}(u) = \begin{cases} 100, & u \le T \\ \max\left(0,\ 100 + 100 \cdot \dfrac{T-u}{T}\right), & u > T \end{cases}$$

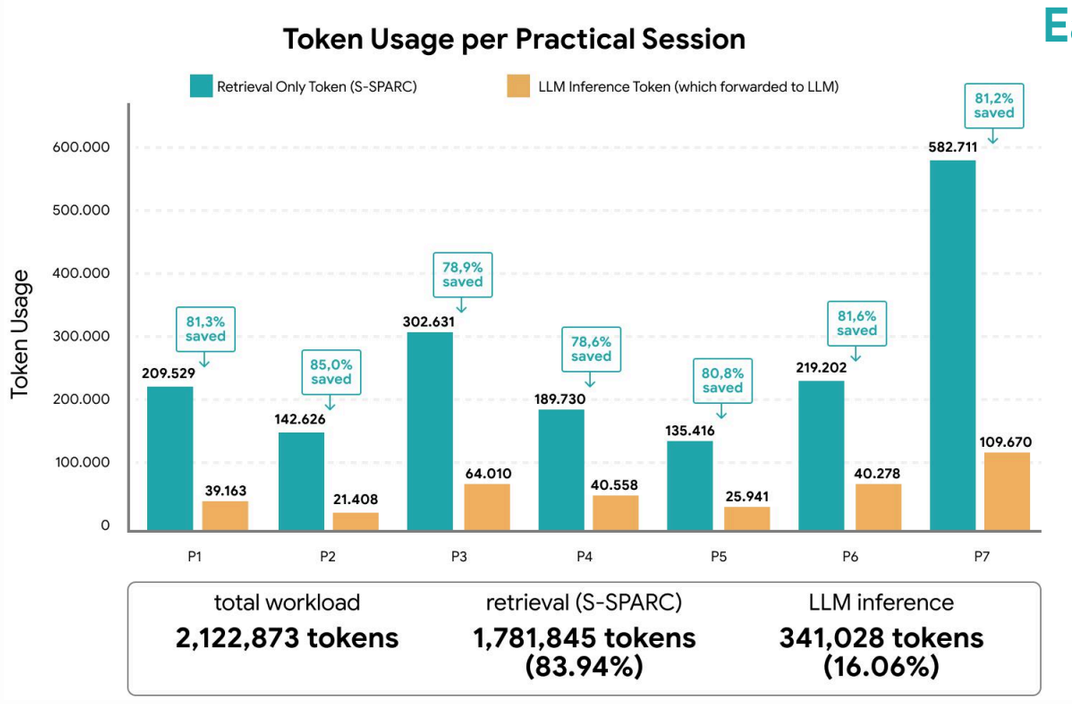
T = dynamic threshold $= 1.10 \times u$
u = weekly token usage of a learner

Environmental Impact Estimation
Measures environmental impact through token-based energy metrics

$$E_{kWh} = \frac{t \cdot e(t)}{1000}, \quad CO_2e_{kg} = E_{kWh} \cdot CIF$$

t = total tokens produced $H_2O_{liters} = 0.19$ L / execution
$CIF = 0.384\ \text{kgCO}_2e/kWh$

$$e(t) = \begin{cases} 2.1775 \times 10^{-3}\ \text{Wh/token}, & t \le 400 \\ 1.5805 \times 10^{-3}\ \text{Wh/token}, & 400 < t \le 2000 \\ 4.2026 \times 10^{-4}\ \text{Wh/token}, & t > 2000 \end{cases}$$



Early Findings

Potential Benefits for Cost and Sustainability
By minimizing LLM usage, S-SPARC reduces operational costs and lowers computational resources required for AI inference, supporting sustainable AI deployment in education.

Significant Reduction in LLM Inference
The S-SPARC system reduced the number of tokens processed by the external LLM by 83.94%, with only 16.06% of the total workload requiring LLM inference.

Improved Retrieval Performance Over Time
Token usage through retrieval steadily increased across sessions, peaking at 582,711 tokens in P7, indicating continuous growth of the knowledge base and lower dependence on cloud AI.

Conclusion

S-SPARC demonstrates that optimized RAG and gamified incentives successfully foster green AI habits without compromising educational quality. Future work will expand validation across more courses, extend controlled experiments, and personalize gamification thresholds.

References

References and full technical documentation are available at:
https://github.com/06202003/s-sparc