Converting Natural Language From Complex Procedural Documents To Structured Diagrams

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Motivation

- The volume of procedural documents is rapidly increasing across technical, legal, and organizational domains.
- Manually interpreting such documents is time-consuming, labor-intensive, and often requires domain expertise.
- Visual representations such as flowcharts significantly reduce cognitive load and aid procedural comprehension.
- Advances in large language models and retrieval techniques offer new potential for intelligent document understanding and visualization.
- There is currently no standard metric for evaluating the transformation from textual procedures to structured flowcharts.

Objectives

- Develop a method to transform procedural documents into interactive flowcharts with support for clarification queries.
- Implement an evaluation framework and experiment to measure the effectiveness of AI in converting documents into flowcharts.
- Deliver a system that is user-friendly and supports expert-guided refinement through a human-in-the-loop approach.

Natural Language Understanding

LLMs apply transformer-based attention to understand context, semantics, and procedural flow, allowing them to identify steps, conditions, and relationships in unstructured text.

Actors & Features

Actors:

- **User (Document Provider):** technical staff, analyst, or researcher who uploads documents and explores flowcharts.
- **AI Engine (IUFlowGen):** automated system that uses LLMs and retrieval to generate draft flowcharts and answer queries.
- **Verifier (Expert):** domain expert who reviews, validates, and optionally refines the AI-generated flowchart.

Features:

- **Send Document** — performed by User, Verifier
- **Plot and Query** — performed by AI Engine
- **Verify and Feedback** — performed by Verifier
- **Interact and Ask** — performed by User, Verifier

Contributions

Scientific Contribution

Formalize a modular AI pipeline that combines retrieval, prompting, and DOT visualization, and propose a metric to evaluate the effectiveness of transforming complex documents into structured flowcharts.

Real-world Contribution

Aid users in understanding procedural documents through interactive visual flowcharts, applicable in education, healthcare, technical documentation, and many more.

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Advancements

- GenFlowchart applies generative AI to understand and segment flowchart diagrams.
- Lester et al. introduce multi-phase summarization for long regulatory documents.
- ChatGPT identifies procedural steps and actors using advanced NLU capabilities.
- Eraser Flowchart Maker supports text-to-diagram generation with intuitive UI.

Research Gaps

Research gap 1

Current AI systems lack interactive flowchart generation that preserves procedural logic and structure from unstructured documents.

Research gap 2

The combination of AI-guided generation with graph and vector representations for storing and retrieving steps, entities, and relationships is still under-discovered in procedural document understanding.

$\Rightarrow$ **A new approach that builds graph-augmented prompts and renders interpretable flowcharts locally can fill this gap.**

Technical difficulties

- The amount of background knowledge required to combine graph theory, vector search, and prompt engineering is substantial.
- LLMs are probabilistic, which introduces unpredictability in output consistency, especially for structured generation tasks.
- Mapping AI-generated content into structured and verifiable DOT code demands careful post-processing and validation.

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System overview

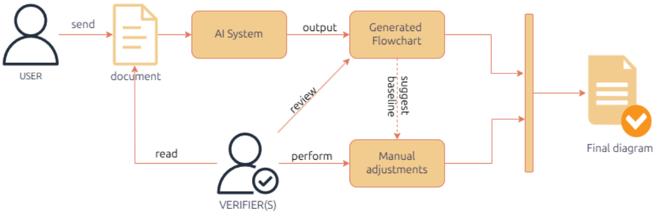
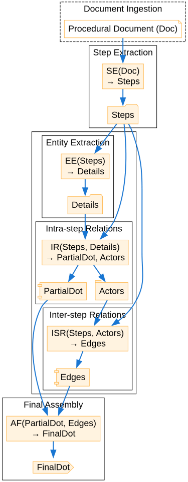


Figure: System overview of UIFLowGen Protocol

Process - Flowchart Generation

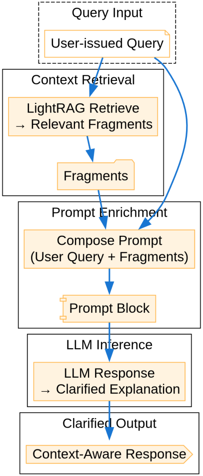
Algorithm Pseudocode



- **Goal:** convert procedural documents into structured flowcharts via automated step/entity extraction and reasoning.
- **Result:** generate a valid FinalDot representation used for rendering interactive flowcharts.
- **Step:** extract steps → enrich with entities → infer relations → assemble graph.
- **Scope:** execute locally with LLMs, LightRAG, regex post-processing, ensuring offline reproducibility.

Process - Query

Algorithm Pseudocode



- **Goal:** support users and verifiers in exploring or confirming specific flowchart elements or logic.
- **Result:** generate a context-aware explanation or inference tied to queried nodes or actions.
- **Step:** receive query → retrieve relevant content → compose enriched prompt → return response.
- **Scope:** acts as an interactive support layer during review.

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Prototyping

GitHub repository: `https://github.com/Khim3/IUFlowGen`

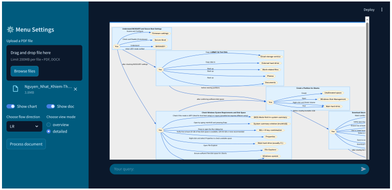

Figure: Generated flowchart from document.

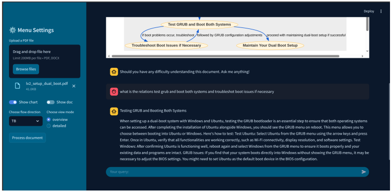

Figure: Clarification query interface

Benchmark Results

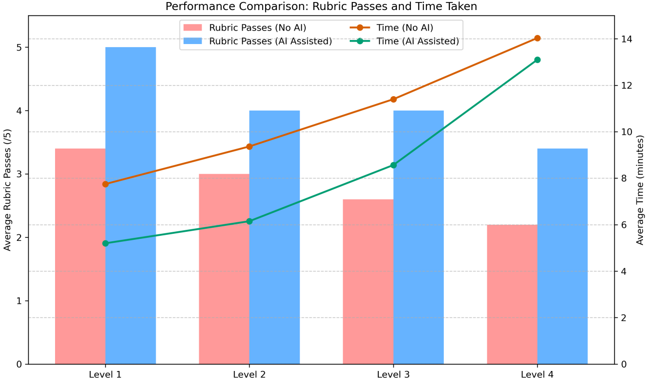

Figure: Comparison of average rubric and time across document complexity levels.

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Analysis

- The system provides high interpretability and transparency by visualizing extracted procedural logic in a human-readable form.
- The interactive human-in-the-loop model empowers domain experts to validate and refine AI-generated flowcharts.
- IUFlowGen adapts well to varying document complexity, demonstrating strong flexibility across synthetic and real-world texts.
- Designed to operate on local infrastructure, the system performs reliably in resource-constrained or offline environments.

Limitations

- Entity extraction and semantic embedding are resource-intensive, causing latency on low-power machines.
- LLM-based generation is non-deterministic, leading to occasional inconsistencies that require human correction.
- The system supports only single-user, sequential document processing, limiting scalability in multi-user scenarios.
- Performance depends on the clarity and structure of the input document, especially for domain-specific texts.

$\Rightarrow$ **Despite these limitations, IUFlowGen establishes a reliable base for AI-assisted procedural understanding in secure, offline contexts.**

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Summary

- **Built for many applications:** IUFlowGen enables automated, interactive flowchart generation from procedural text, suitable for use in education, healthcare, compliance, and technical documentation, etc.
- **Ready for practical adoption:** Designed for offline deployment, IUFlowGen is accessible to end users, organizations, and domain experts needing secure document visualization tools.

Future Works

- Improve UI/UX design with real-time feedback, interactive previews, and adjustable layout controls for better user experience.
- Enable direct flowchart editing, including drag-and-drop, node repositioning, and in-place corrections.
- Package the system for web or mobile deployment to improve accessibility in education, legal, and enterprise settings.

Demonstration

Process A

Visualize the flowchart from an uploaded procedural document.

Scenario 1

Successful generation and rendering of a valid procedural flowchart.

Scenario 2

Clarification query triggered on a node to retrieve related explanation.

Process B

Perform a query from the generated chart to aid user understanding.


thank
you!