Dynamic LaTeX Generator Using PyLaTeX and PyQt

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1 Introduction

Automating report generation with LaTeX is an essential part of structured reporting in many technical and academic fields. This project aims to create an interactive system that allows users to personalize LaTeX-generated reports by choosing certain components to be included. By using PyLaTeX for creating LaTeX documents and PyQt for GUI programming, this solution offers a convenient method for selective content generation.

The system takes individual segments from a pre-created LaTeX file, displays them in an easy-to-use GUI, and permits users to select dynamically the pieces they wish in the output. After selection, the system generates a polished LaTeX document and saves it as a PDF, promoting flexibility and ease of report creation. This method is especially useful in situations where modular documentation is needed, like research articles, technical guides, and automated reporting systems. Through the combination of PyLaTeX and PyQt, this implementation fills the gap between automated document processing and user-driven customization, providing a scalable and efficient solution for dynamic LaTeX report generation.

2 Problem Statement

Let D be a structured LaTeX document composed of n components, $C = \{C_1, C_2, \ldots, C_n\}$. Traditional LaTeX reports include all components by default, requiring manual editing to customize content, which is inefficient.

This project formulates the problem as a **component selection task**, where a function $S : C \to C'$ (where $C' \subseteq C$) determines the subset of components for the final document. Given a LaTeX file T, the system must:

1. Extract all sections C_i from T.
2. Provide a user interface U for selecting C'.
3. Generate a new LaTeX file T' containing only C'.
4. Compile T' to produce a customized PDF $P(C')$.

Mathematically,

$$P(C') = \mathcal{F}(S(C), T) \tag{1}$$

where $\mathcal{F}$ is the LaTeX compilation function.

By integrating **PyLaTeX** for document processing and **PyQt** for UI interaction, this system automates **dynamic LaTeX report generation**, improving efficiency and flexibility.

2.1 Objective

Develop a **dynamic LaTeX report generation system** that enables selective content inclusion through a graphical user interface. The specific objectives include:

1. **Automated Component Extraction:**
   - Parse the LaTeX document T to identify distinct components $C = \{C_1, C_2, \ldots, C_n\}$.
   - Structure components dynamically for modular selection.
2. **Graphical User Interface (GUI) Development:**
   - Implement an interactive selection interface U using **PyQt**.
   - Enable real-time visualization of LaTeX components.
3. **Customizable Document Generation:**
   - Define a selection function $S : C \to C'$ to filter relevant components $C' \subseteq C$.
   - Dynamically construct a new LaTeX file T' containing only C'.
4. **Efficient LaTeX Compilation and PDF Generation:**
   - Ensure seamless processing of T' using **PyLaTeX**.
   - Validate structural integrity and maintain formatting consistency in the generated PDF $P(C')$.

5. **Scalability and Performance Optimization:**
    - Optimize parsing, selection, and compilation processes for efficiency.
    - Design the system to support large-scale LaTeX documents with multiple components.

By achieving these objectives, the project ensures an automated, user-friendly, and efficient **component-based LaTeX report generation system**, reducing manual intervention while enhancing flexibility and customization.

3 Methodology

The methodology consists of a structured pipeline for extracting, selecting, and compiling LaTeX components into a customized document. The approach follows these key steps:

1. **Component Extraction:** The system parses the LaTeX document T and identifies structural elements such as sections, tables, and figures. Using regular expressions, components $C = \{C_1, C_2, \ldots, C_n\}$ are extracted for modular selection.

2. **User Selection Interface:** A graphical interface U built with PyQt allows users to choose components $C' \subseteq C$. The selection is stored dynamically to generate a tailored report.

3. **Dynamic Document Construction:** A new LaTeX file T' is created, containing only the selected components C'. The content structure is preserved to maintain formatting consistency.

4. **PDF Compilation:** The customized LaTeX file T' is compiled using PyLaTeX, generating the final PDF $P(C')$.

5. **Validation and Optimization:** The system ensures correctness through syntax validation and optimizes the parsing and compilation process for efficiency.

4 Computational Framework

The system performs structured operations to transform a full LaTeX document T into a customized subset T'. The key computations involved are:

1. **Component Identification:**
   - Given a document T, we extract n components, denoted as:
   $$C = \{C_1, C_2, \ldots, C_n\} \tag{2}$$
   - Using pattern matching techniques (e.g., regular expressions), we identify sections, tables, and figures.
2. **Component Selection Function:**
   - A user selects a subset of components $C' \subseteq C$, forming a selection function:
   $$S : C \to C' \tag{3}$$
   - The number of possible selections follows the power set property:
   $$|P(C)| = 2^n \tag{4}$$
   where $P(C)$ is the power set of C.
3. **LaTeX Compilation Complexity:**
   - Given the selected components C', a new LaTeX document T' is generated:
   $$T' = \bigcup_{C_i \in C'} C_i \tag{5}$$
   - The document is then compiled to produce a PDF $P(C')$ using PyLaTeX:
   $$P(C') = \mathcal{F}(T') \tag{6}$$
   where $\mathcal{F}$ represents the LaTeX compilation function.
4. **Efficiency Considerations:**
   - The computational complexity of parsing T and extracting C is approximately:
   $$O(n) \tag{7}$$
   assuming a linear scan of the document.
   - The user selection and filtering operation runs in:
   $$O(k) \tag{8}$$
   where k is the number of selected components.
   - The final LaTeX compilation depends on the document size but is generally:
   $$O(m \log m) \tag{9}$$
   where m is the number of LaTeX tokens processed.

5 Expected Outcomes

The proposed system for **component-based LaTeX report generation** is expected to achieve the following technical outcomes:

1. **Automated LaTeX Component Parsing**
   - Efficient extraction of sections, tables, and figures from structured LaTeX files using **regular expressions** and **pattern matching algorithms**.
   - Improved document modularity through dynamic segmentation of content.
2. **Interactive User-Driven Content Selection**
   - Real-time **graphical user interface (GUI) integration** using **PyQt** for seamless selection of report components.
   - Intuitive preview of selected components before generating the final document.
3. **Optimized Report Generation Pipeline**
   - Dynamic construction of a **customized LaTeX document** by selectively including relevant components.
   - Execution of efficient **LaTeX-to-PDF compilation** using **PyLaTeX** with minimal latency.
4. **Mathematical Validation and Consistency**
   - Preservation of mathematical expressions, equations, and tabular data within the generated document.
   - Error handling for missing references, formatting inconsistencies, and compilation failures.
5. **Performance and Scalability Enhancements**
   - Reduction in manual intervention by automating component extraction and selection.
   - Scalability to handle **large LaTeX documents** with multiple sections and nested environments.

6 Flowchart

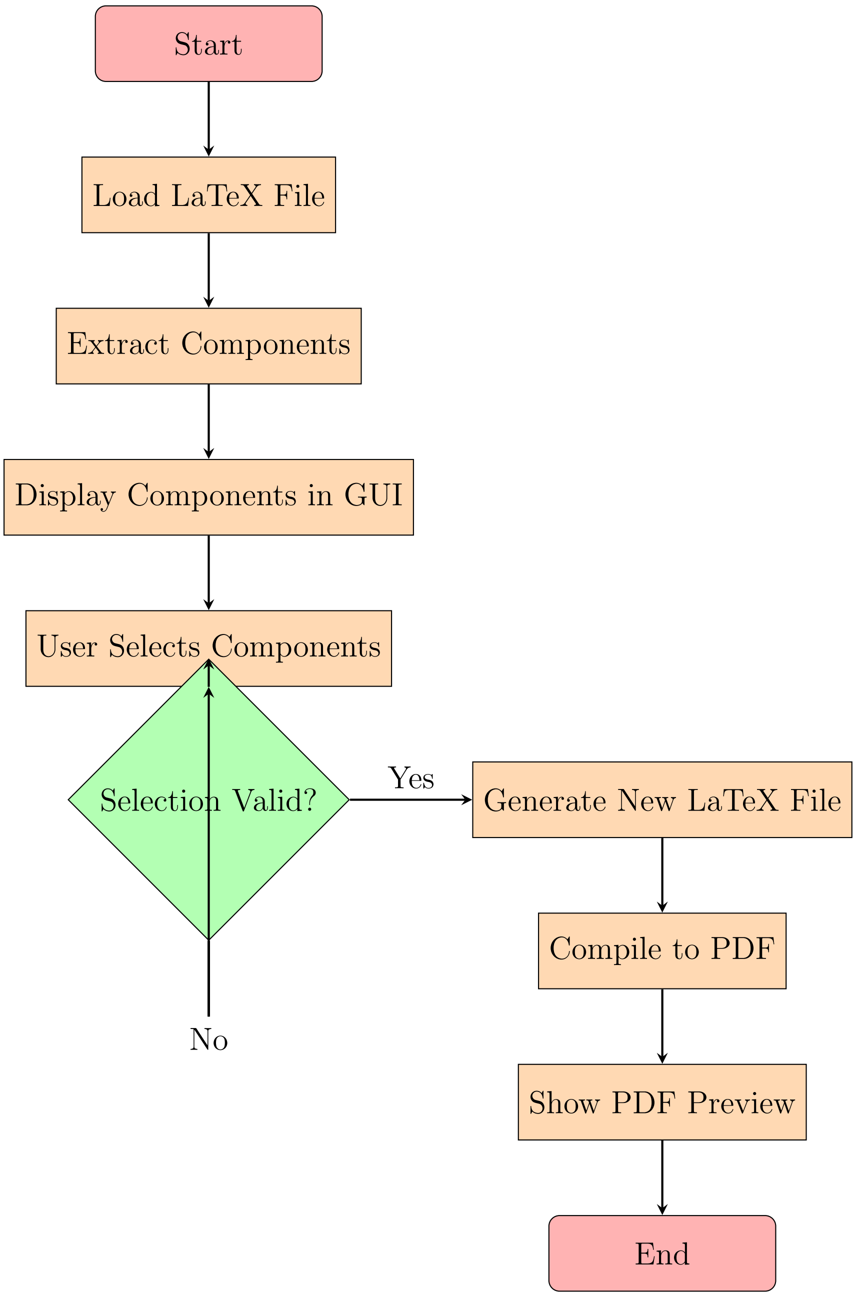

Figure 1: Flowchart for LaTeX Report Component Selection

7 Example Solution in Python

```python
import sys
import re
import os
from PyQt6.QtWidgets import (
    QApplication, QWidget, QVBoxLayout, QListWidget, QPushButton, QTextBrowser, QLabel, QFileDialog
)
from PyQt6.QtGui import QPixmap
from pdf2image import convert_from_path
from pylatex import Document, NoEscape


class ReportSelector(QWidget):
    def __init__(self):
        super().__init__()
        self.setWindowTitle("Select Report Components")
        self.setGeometry(100, 100, 600, 500)

        # Layout
        layout = QVBoxLayout()

        # List Widget for components
        self.list_widget = QListWidget()
        self.list_widget.setSelectionMode(QListWidget.SelectionMode.MultiSelection)

        # Load LaTeX file
        self.tex_file = r"C:\Users\rktej\Desktop\Latex\FOSSEE_SUMMER_FELLOWSHIP_SAMPLE_TEX.tex"  # Change as needed
        self.components = self.extract_components(self.tex_file)

        # Add components with generic names (Component 1, Component 2, etc.)
        for i in range(len(self.components)):
            self.list_widget.addItem(f"Component {i+1}")

        # Button to generate report
        self.generate_btn = QPushButton("Generate Report")
        self.generate_btn.clicked.connect(self.generate_report)

        # Preview Text Browser
        self.preview = QTextBrowser()

        # PDF Preview Label
        self.pdf_preview = QLabel()

        # Add Widgets to Layout
        layout.addWidget(self.list_widget)
        layout.addWidget(self.preview)
        layout.addWidget(self.generate_btn)
        layout.addWidget(self.pdf_preview)

        self.setLayout(layout)

        # Store previous selections
        self.selected_text_list = []

    def extract_components(self, file_path):
        """Extract sections, tables, and figures from a LaTeX file."""
        components = []
        with open(file_path, "r", encoding="utf-8") as file:
            content = file.read()

            # Extract Sections, Tables, and Figures
            matches = re.findall(r'(\\section{.*?}|\\begin{table}.*?\\end{table}|\\begin{figure}.*?\\end{figure})', content, re.DOTALL)
            components.extend(matches)

        return components

    def generate_report(self):
        """Generate a LaTeX report using PyLaTeX with selected components without replacing previous selections."""
        selected_items = self.list_widget.selectedItems()
        selected_indices = [int(item.text().split()[-1]) - 1 for item in selected_items]
        selected_text = "\n".join([self.components[i] for i in selected_indices])

        if not selected_text:
            self.preview.setText("No components selected!")
            return

        # Append newly selected components
        self.selected_text_list.append(selected_text)
        final_text = "\n".join(self.selected_text_list)

        self.preview.setText(final_text)

        # Ask user where to save the report
        save_path, _ = QFileDialog.getSaveFileName(self, "Save Report", "custom_report.pdf", "PDF Files (*.pdf)")
        if save_path:
            save_path = self.get_unique_filename(save_path)  # Ensure unique file names
            self.compile_tex_to_pdf(save_path, final_text)
            self.show_pdf_preview(save_path.replace(".pdf", ".pdf"))  # Ensure correct path

    def compile_tex_to_pdf(self, save_path, selected_text):
        """Use PyLaTeX to compile selected components into a PDF."""
        doc = Document()  # PyLaTeX automatically includes \documentclass and \begin{document}
        doc.append(NoEscape(selected_text))  # Append only selected content
        doc.generate_pdf(save_path.replace(".pdf", ""), clean_tex=False, compiler="pdflatex")


    def show_pdf_preview(self, pdf_path):
        """Convert first page of the generated PDF to an image and display."""
        images = convert_from_path(pdf_path)
        images[0].save("preview.png", "PNG")
        pixmap = QPixmap("preview.png")
        self.pdf_preview.setPixmap(pixmap)

    def get_unique_filename(self, file_path):
        """Generate a unique filename if a file with the same name already exists."""
        base, ext = os.path.splitext(file_path)
        counter = 1
        new_path = file_path

        while os.path.exists(new_path):
            new_path = f"{base}_{counter}{ext}"
            counter += 1

        return new_path


if __name__ == "__main__":
    app = QApplication(sys.argv)
    window = ReportSelector()
    window.show()
    sys.exit(app.exec())
```

8 Conclusion

This report presents a dynamic LaTeX report generation system integrating PyLaTeX and PyQt to enable selective component inclusion. By automating LaTeX parsing, modular content selection, and PDF compilation, the system enhances efficiency, flexibility, and user control over document customization. The approach ensures scalability, minimal manual intervention, and seamless adaptability to various structured documents, making it suitable for academic, research, and technical reporting applications.

9 References

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