Web Application for the MML Explanation

Yuta Teruya[1], Kazuhisa Nakasho[1,*]

[1]Yamaguchi University, 2-16-1 Tokiwa-dai, Ube, Japan

Abstract
This paper reports on the development of a web application that hosts articles from the Mizar Mathematical Library (MML). In this application, explanatory articles are written in Markdown notation, and MathJax is used to render mathematical expressions and embed MML content within the articles. This approach allows for the creation of structured explanatory articles, as opposed to the traditional method of inserting annotations directly into a formalized library. The posted explanatory articles can be referenced from the corresponding HTMLized MML page. Additionally, the hosting platform for this application, emwiki, integrates a remote verification environment. This feature allows Mizar users to develop libraries without needing to install the Mizar system and editor locally, enhancing convenience. Our new application is embedded in emwiki, an integrated web platform developed to host the Mizar Mathematical Library.

Keywords
Mizar, Mizar Mathematical Library (MML), Web platform integration, Library explanation, Remote development

1. Introduction

In recent years, there has seen significant progress in the formalization of mathematical libraries. A notable example of this advancement is the Mizar project [1], initiated by Andrzej Trybulec and his colleagues to support the formalization of a unified mathematical library [2]. Trybulec, who combined his expertise as both a computer scientist and a mathematician, designed the Mizar language. The Mizar language achieves a balance between precise mathematical encoding that computers can process and a level of readability that humans can understand [3, 4].

Although the Mizar language is more readable than many formal languages, it remains less accessible than the natural language used in traditional mathematical papers. Consequently, researchers often publish separate papers to explain the formalizations in the Mizar Mathematical Library (MML). To address this challenge, we have developed a new web application.

Our application introduces several key features:

1. A blog-style format for posting explanatory articles about the MML, improving accessibility and readability.
2. Integration of Markdown notation for writing articles, enabling structured and easily formatted content.

MathUI 2024: 15th Workshop on Mathematical User Interaction, August 05–09, 2024, Montréal, Québec, Canada
*Corresponding author.
nakasho@yamaguchi-u.ac.jp (K. Nakasho)
0000-0003-1110-4342 (K. Nakasho)
© 2023 Copyright for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).
CEUR Workshop Proceedings (CEUR-WS.org)

3. Utilization of MathJax[1] for rendering mathematical expressions, ensuring clear and accurate mathematical notation.
4. A feature for embedding MML content directly within explanatory articles, providing immediate access to formal definitions and theorems.
5. Cross-referencing capabilities, allowing users to navigate between HTMLized MML pages and related explanatory articles.

Furthermore, we have integrated a remote verification environment into our platform, eliminating the need for local installation of the Mizar system and editor. This integration creates a comprehensive environment where users can browse the library, create explanatory articles, and develop the MML, all within a single platform.

This paper details the development and features of our web application, demonstrating how it enhances the accessibility and usability of the MML. By providing a unified environment for Mizar development and documentation, we aim to accelerate the progress of formalized mathematics and make it more accessible to the broader mathematical community.

The newly developed application is available at the following URL:

https://em1.cs.shinshu-u.ac.jp/emwiki/release/

2. Related Works

2.1. MathWiki Project

The MathWiki Project aimed to create a Wikipedia-like platform for formalized mathematics. It developed a wiki-style web application that enabled users to work with theorems from various formal libraries created by different interactive theorem provers (ITPs) [5]. Users could extract theorems with similar meanings and add explanations using LaTeX-style notation.

This project introduced several innovative systems, including A Wiki for Mizar [6], Large Formal Wikis for Coq/CoRN [7], and the Agora System for the Flyspeck Project [8]. The web-based format of these systems allowed users to access them via the internet without needing to install software locally. This approach made formal mathematics more accessible to a wider audience. The platform also supported the addition of comments using mathematical notation, enhancing the explanatory power of the wiki.

However, the MathWiki Project faced some significant challenges. One major issue was that the comments added by users did not automatically update when the formal libraries were modified. This could lead to inconsistencies between the explanations and the actual content of the libraries. Unfortunately, another limitation emerged as the project has since ended, and its website is no longer available. This development limits the long-term impact and accessibility of the work done within the project.

Despite these issues, the MathWiki Project represented an important step in making formalized mathematics more accessible and understandable to a broader audience. It demonstrated the potential of collaborative platforms in bridging the gap between formal mathematical libraries and their human-readable explanations.

[1]https://www.mathjax.org/

2.2. Formalized Mathematics

Formalized Mathematics, a quarterly journal established in 1990, plays a crucial role in distributing formalized mathematical knowledge. It publishes summaries of Mizar articles contributed to the MML. The journal employs a unique two-step process: first, papers are verified by the Mizar system, ensuring mathematical correctness; then, they are mechanically translated into English for broader accessibility.

This approach guarantees formal accuracy but presents challenges in readability. The mechanical translation often results in papers that lack the natural flow of manually written mathematical texts, making it difficult for readers to fully grasp the underlying concepts. Despite this limitation, Formalized Mathematics serves as a valuable link between formal mathematical proofs and the wider mathematical community. It highlights the ongoing challenge in formal mathematics of balancing machine-verifiable precision with human-readable mathematical exposition.

2.3. Mathematical Components

The Mathematical Components project is a significant advancement in formalized mathematics, developed using the Coq proof assistant [9]. This comprehensive library has been instrumental in tackling complex mathematical challenges, most notably in the formalization of the Feit–Thompson Theorem.

The project's website serves as a multifaceted resource, offering direct access to the library, hosting related academic papers, and providing detailed documentation. A key feature is the inclusion of dependency graphs, which visualize the relationships between different components of the library. Each library's source files are accompanied by comprehensive documentation, explaining introduced concepts and notations. This approach to library development and dissemination establishes Mathematical Components as a model for accessibility in formalized mathematics, catering to both experts and newcomers in the field.

2.4. Isabelle Documentation

Isabelle is an advanced ITP system, developed collaboratively by the University of Cambridge and the Technical University of Munich [10]. It features Isar, a structured proof language designed to create proofs that are understandable by both humans and computers [11]. Notably, Isar was developed with significant inspiration from the Mizar language, adopting its approach to creating human-readable formal proofs while leveraging Isabelle's powerful automation capabilities.

The Isabelle documentation page serves as a comprehensive resource, offering access to the library's source code, PDF documents explaining the system and formalization techniques, and dependency graphs. These graphs visually represent the relationships between different theories within Isabelle, aiding users in navigating the complex structure of the formal mathematical library. This combination of accessible code, detailed documentation, and visual aids makes the Isabelle documentation an exemplary model for enhancing the usability of advanced ITP systems among mathematicians and computer scientists of varying expertise levels.

2.5. Lean ZulipChat

Lean ZulipChat represents an innovative approach to collaborative learning and problem-solving in the field of ITP. This online platform serves the community of users and developers of Lean, a prominent ITP system developed by Microsoft Research in 2013 [12]. Lean has quickly gained popularity among mathematicians and computer scientists for its powerful capabilities in formalizing mathematical proofs.

The chat platform provides a dynamic environment where users can engage in real-time discussions about various aspects of Lean and formal mathematics. It facilitates a wide range of interactions, from novices asking fundamental questions to experts coordinating complex formalization projects [13]. This open communication channel has proven instrumental in accelerating the learning curve for new users and fostering collaboration on advanced mathematical formalizations. Lean ZulipChat has evolved into an essential resource for the Lean community, effectively bridging the gap between formal mathematical theory and practical implementation. By enabling rapid knowledge sharing and collaborative problem-solving, it has significantly contributed to the growth and accessibility of formal mathematics in the digital age.

2.6. emwiki

The emwiki system[2] is a web platform developed to host the MML [14, 15]. Building upon the concepts of the MathWiki Project [7], emwiki aims to improve the readability and accessibility of articles written in the Mizar language. The platform uses a modular design to facilitate the addition of new features and promote cooperation between functions.

The emwiki system offers three main features. First, it provides wiki functionality that allows users to add comments to the HTMLized MML [15]. While users cannot edit the formal mathematical descriptions directly, they can add annotations using MathJax for mathematical notation rendering. This feature supports both annotation of the MML and collaborative discussions. Also, this annotation feature is designed to follow library updates by using Git's merge function. Second, the system includes a search function [16] that helps users find articles, symbols, and theorems within the MML. This feature is designed to improve access to information within the library. Third, emwiki includes a graph display function [17] that shows the dependency relationships between MML articles using hierarchical graphs. Based on the Sugiyama framework [18], these graphs aim to clarify the connections within the MML. Additional features such as node highlighting, searching, and zooming are also available to help users navigate the MML structure.

Figure 1 shows an example of an article screen in emwiki. The emwiki system attempts to make formalized mathematics more accessible by providing these features, aiming to bridge the gap between formal mathematical representations and more readable explanations.

[2] https://em1.cs.shinshu-u.ac.jp/emwiki/release/

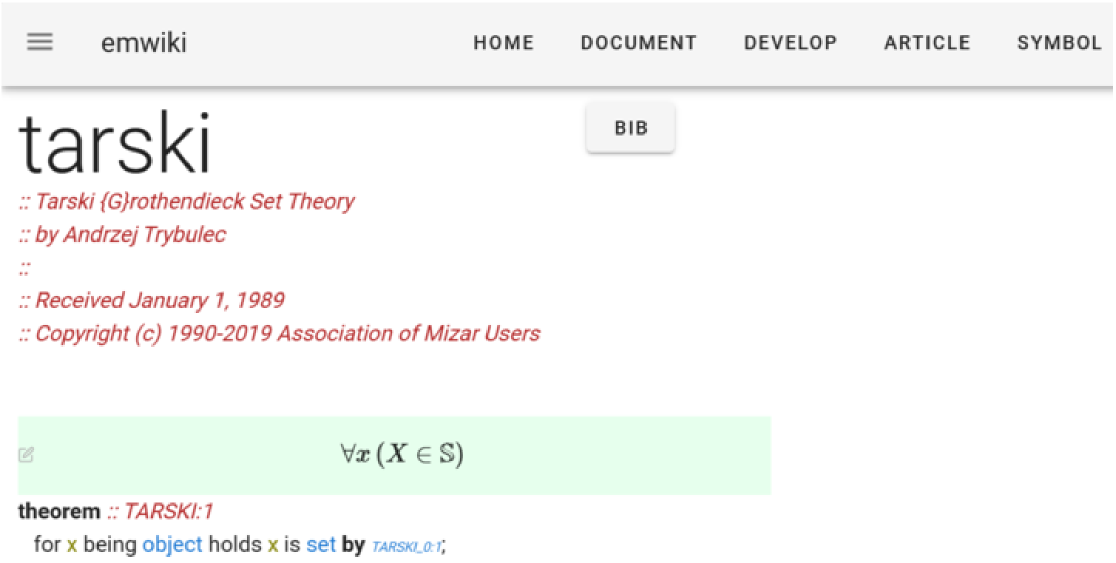

Figure 1: Article in emwiki

3. Implemented Features

3.1. Creation of Explanatory Articles

Formal mathematical libraries, while precise, often lack the readability of traditional mathematical papers. These libraries typically contain only definitions and theorems, without the explanatory context found in mathematical textbooks. Their structure rarely follows a logical order that humans find easy to follow. To address this issue, researchers often publish separate papers explaining these formalized libraries.

Our research introduces a new application that integrates explanatory articles within the same platform as the formalized library. This approach aims to overcome the readability challenges associated with formal mathematical libraries. The application allows users to embed MML content directly into explanatory articles written in natural language. This feature enables the creation of comprehensive articles that combine formal mathematical content with clear, accessible explanations. To promote collaboration, the system allows any registered user to edit articles. To maintain transparency and track changes, the application automatically records edit histories in a dedicated GitHub repository. This feature ensures safe collaborative editing among multiple users. A key advantage of this system is its flexibility in organizing content. Users can reference parts of the formalized library in any order, independent of the library's original structure. This allows for the creation of explanatory materials that follow a more intuitive order, including logical chapter organizations that aid in understanding.

The application we developed offers a user-friendly interface for managing explanatory articles in a blog-like format. Users can easily create, edit, and delete articles as needed. The sidebar, shown in Figure 2, provides quick access to article details and navigation options. To create a new article, users simply click the [CREATE NEW] button. Existing articles can be accessed by clicking their titles in the sidebar. Figure 3 displays the article creation screen. This interface is designed for ease of use, with a text input area on the left and a real-time preview on the right. Users can submit their work using the [SUBMIT] button or discard changes with the [CANCEL] button. For viewing and managing existing articles, users can access a detailed page as shown in Figure 4. This page includes [EDIT] and [DELETE] buttons, allowing for easy editing or removal of articles.

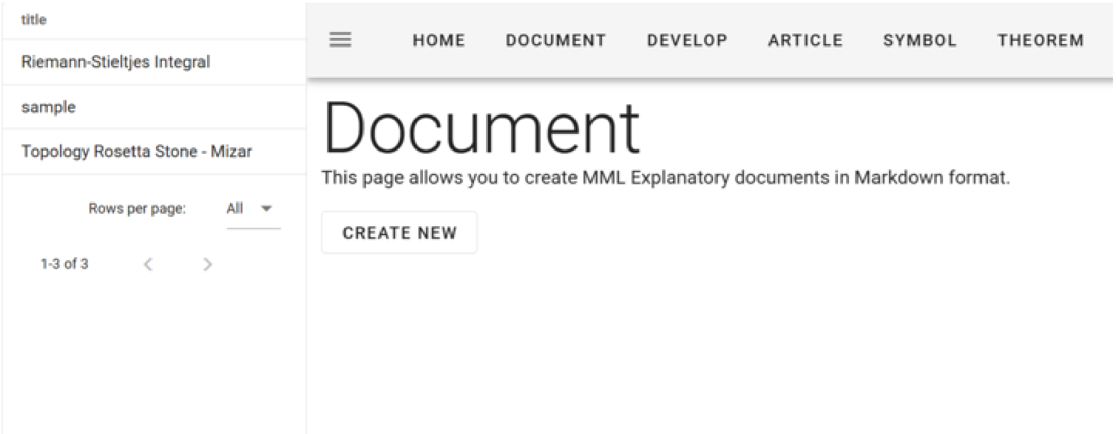

Figure 2: Sidebar of the explanatory article page

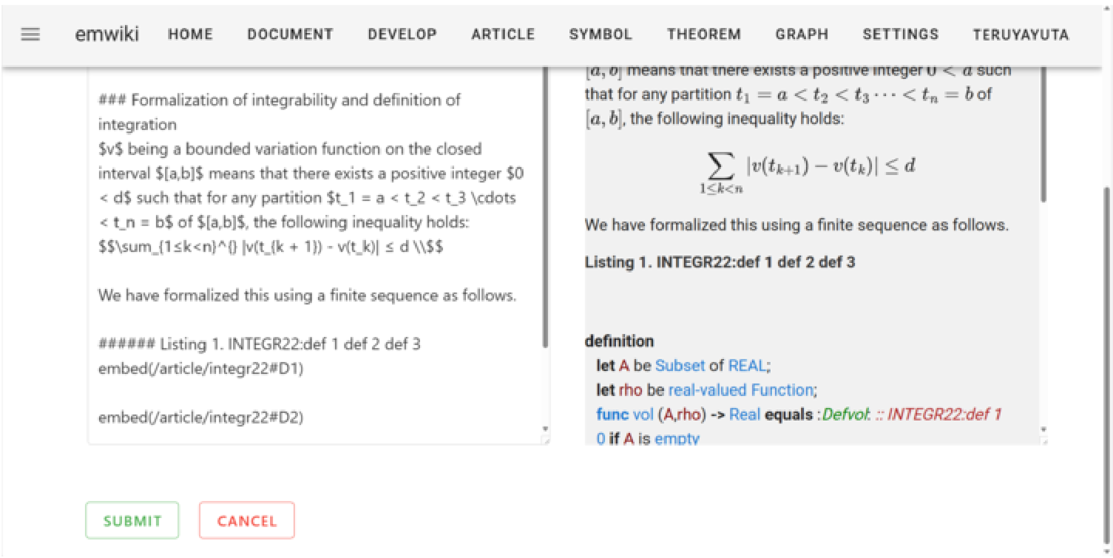

Figure 3: Article creation screen in emwiki

We chose Markdown syntax for article writing due to its widespread use in web document creation. To enhance mathematical content, we integrated MathJax for rendering mathematical notations. As Markdown and MathJax transform the input text into formatted content, we

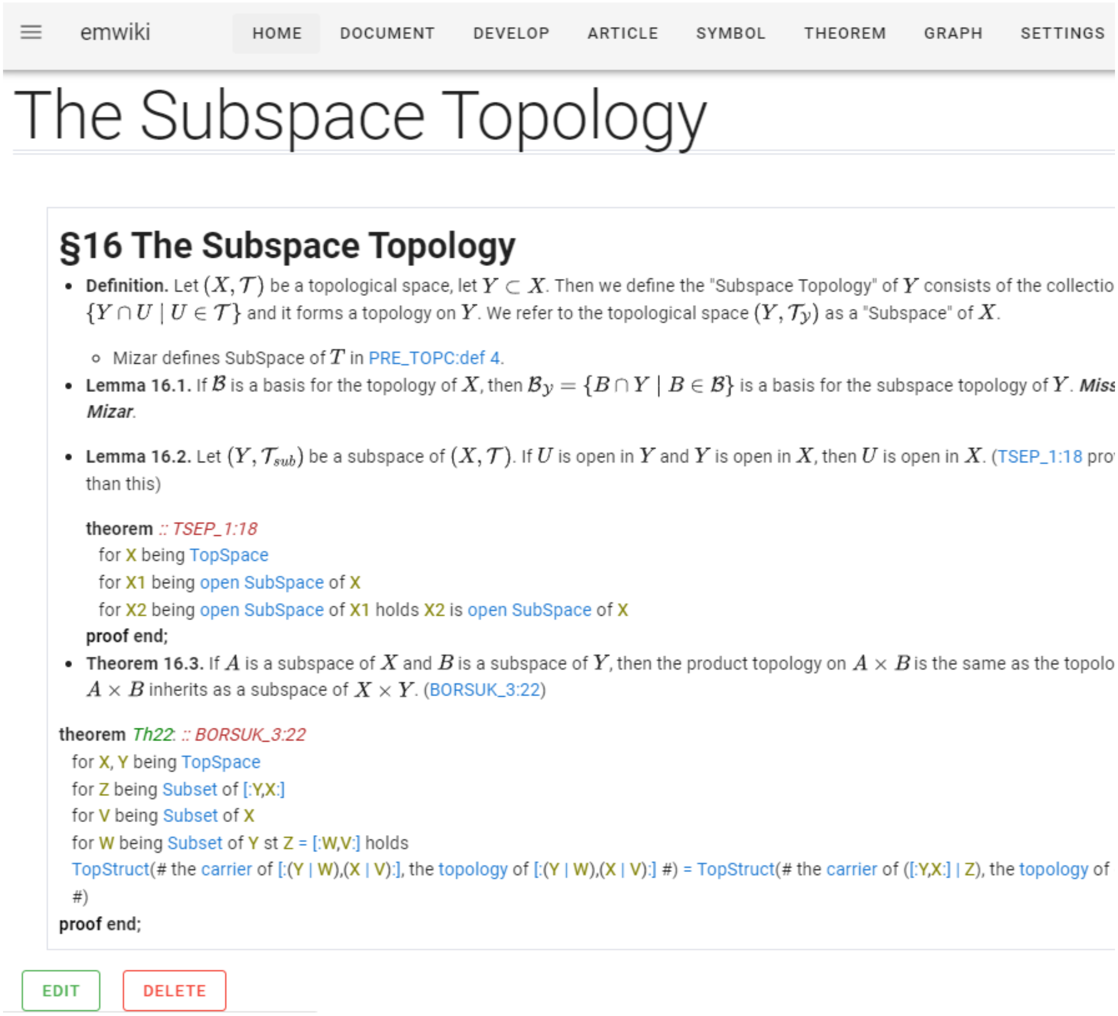

Figure 4: Detailed view of an explanatory article

implemented a live preview feature. This allows users to see how their article will appear, including formatted headings, tables, and equations, as they type. An innovative feature of our application is the ability to embed parts of HTMLized MML [19] directly into articles using the 'embed' keyword. This functionality enables users to reference library descriptions within their explanatory articles, complete with hyperlinks and hover display functions. Figure 5 demonstrates how users can view MML details using the hover function on the detail page. These features collectively aim to make the creation and management of explanatory articles more intuitive and efficient, bridging the gap between formal mathematical content and accessible explanations.

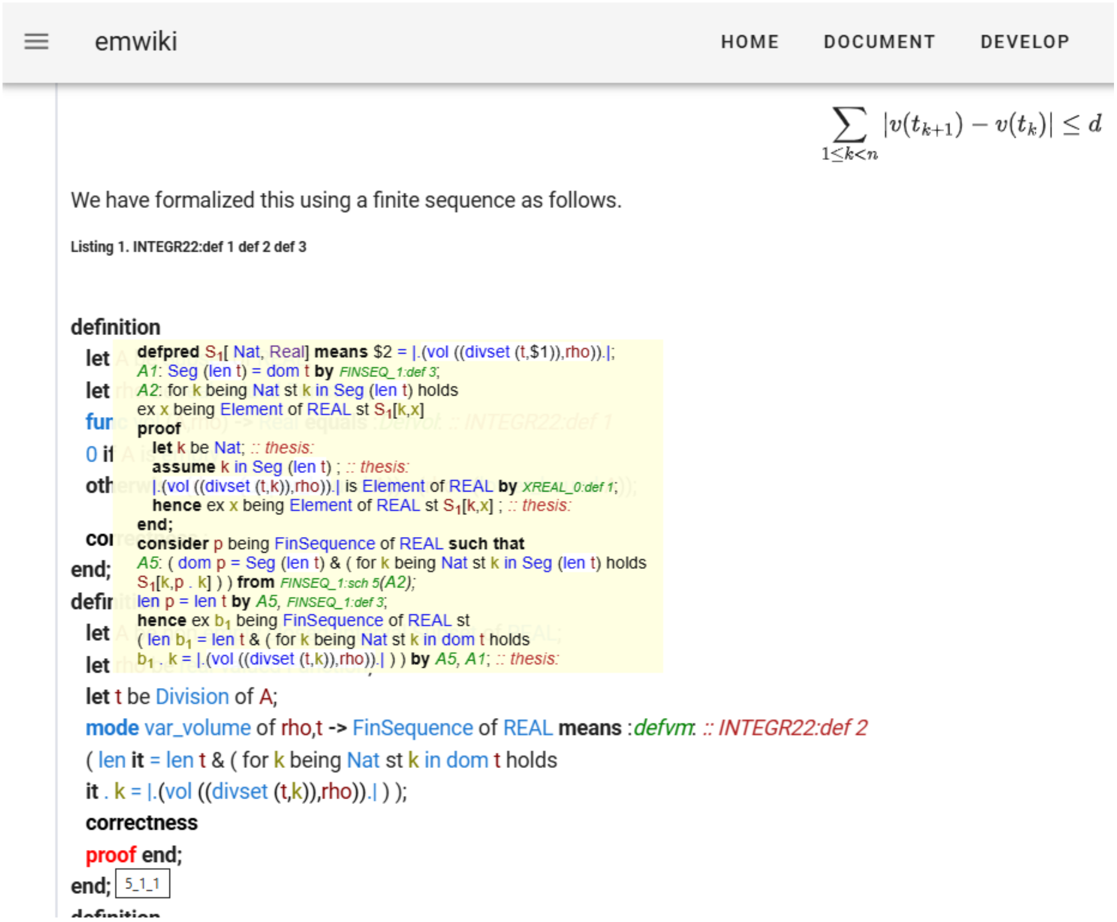

Figure 5: Hover display function for MML details

3.2. Cross-referencing Function from MML to Explanatory Articles

To aid users' understanding, explanatory papers about formalized libraries are often published separately. However, finding the corresponding explanatory articles for theorems included in the library is not always straightforward. Users often spend considerable time searching for these explanatory articles, and users often face uncertainty about whether to create new explanatory content for theorems within the library. To address these issues, we have developed a cross-referencing function that links the MML article with its corresponding explanatory articles. This function creates automatic connections when MML content is embedded in an explanatory article. As a result, each MML article page in emwiki now displays hyperlinks to relevant explanations. This bidirectional approach allows users to navigate easily between formal theorems and their explanations, and vice versa. Figure 6 demonstrates this feature, showing an MML article page with links to related explanatory articles. This function aims to make formalized mathematics more accessible by providing quick access to relevant explanations of formal content.

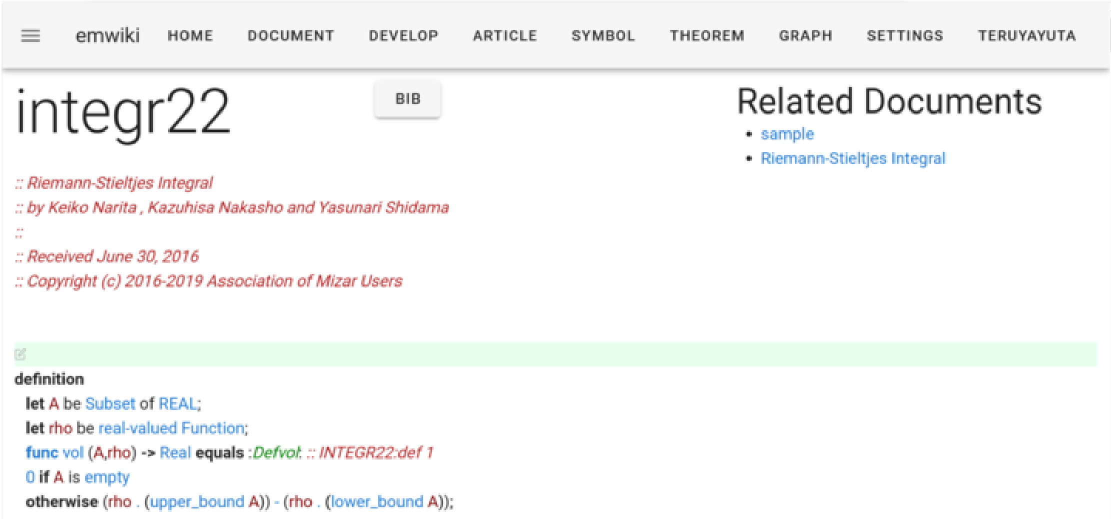

Figure 6: Cross-referencing function from article pages to explanatory articles

3.3. Integration of emwiki and Mizar Remote Verification Environment

Mizar Extension [20] and Mizar Mode [21] are currently the primary editor environments for Mizar. However, these environments require users to install the Mizar system and editors locally, which can be a barrier to entry for new users. To address this issue, recent research has focused on developing a Mizar development environment that does not require local installation [22]. This approach aims to enhance accessibility and convenience for Mizar users. By integrating the Mizar remote verification environment into emwiki, we have created a comprehensive platform that combines library browsing, creation of explanatory articles, and MML development. This integration enables users to seamlessly engage in both Mizar development and documentation within a single, unified environment.

4. Conclusion and Future Work

This paper presented the development of a web application that hosts explanatory articles for the MML using Markdown notation. Our approach offers several key advancements:

1. Adoption of a blog format, facilitating easier creation and editing of MML explanatory articles.
2. Implementation of mathematical notation rendering using MathJax.
3. Integration of a feature to embed MML content within the articles.

These innovations enable the creation of more structured and accessible explanatory articles compared to traditional methods of inserting annotations directly into formalized libraries. Moreover, the posted explanatory articles can be cross-referenced from related HTMLized MML pages, enhancing navigation and understanding. We further integrated a remote verification environment into emwiki, our hosting platform. This integration eliminates the need for local installation of the Mizar system and editor, allowing users to develop libraries, browse the MML and explanatory articles, and create new content all within a single, unified platform. This comprehensive approach contributes significantly to improving MML readability and increasing development efficiency.

Future work will focus on two primary areas:

1. Implementing a robust search function for explanatory articles to manage the anticipated increase in content volume.
2. Developing methods to convert existing PDF-format MML explanatory papers into our application's article format, potentially leveraging generative AI technologies.

These enhancements aim to further streamline the process of working with formal mathematical libraries, making them more accessible to a broader audience of mathematicians and computer scientists.

References

[1] A. Grabowski, A. Kornilowicz, A. Naumowicz, Mizar in a Nutshell, Journal of Formalized Reasoning 3 (2010) 153–245.

[2] P. Rudnicki, An overview of the Mizar project, in: Proceedings of the 1992 Workshop on Types for Proofs and Programs, 1992, pp. 311–330.

[3] G. Bancerek, C. Byliński, A. Grabowski, A. Korniłowicz, R. Matuszewski, A. Naumowicz, K. Pąk, The Role of the Mizar Mathematical Library for Interactive Proof Development in Mizar, Journal of Automated Reasoning 61 (2018) 9–32.

[4] G. Bancerek, C. Byliński, A. Grabowski, A. Korniłowicz, R. Matuszewski, A. Naumowicz, K. Pąk, J. Urban, Mizar: State-of-the-art and beyond, in: International Conference on Intelligent Computer Mathematics, Springer, 2015, pp. 261–279.

[5] J. Urban, Content-based encoding of mathematical and code libraries, in: C. Lange, J. Urban (Eds.), Proceedings of the ITP 2011 Workshop on Mathematical Wikis, Nijmegen, The Netherlands, August 27th, 2011, volume 767 of *CEUR Workshop Proceedings*, CEUR-WS.org, 2011, pp. 49–53. URL: https://ceur-ws.org/Vol-767/paper-09.pdf.

[6] J. Urban, J. Alama, P. Rudnicki, H. Geuvers, A wiki for Mizar: Motivation, considerations, and initial prototype, in: International Conference on Intelligent Computer Mathematics, Springer, 2010, pp. 455–469.

[7] J. Alama, K. Brink, L. Mamane, J. Urban, Large Formal Wikis: Issues and Solutions, in: International Conference on Intelligent Computer Mathematics, Springer, 2011, pp. 133–148.

[8] C. Tankink, C. Kaliszyk, J. Urban, H. Geuvers, Formal Mathematics on Display: A Wiki for Flyspeck, in: International Conference on Intelligent Computer Mathematics, Springer, 2013, pp. 152–167.

[9] F. Steinberg, L. Théry, H. Thies, Quantitative continuity and computable analysis in coq, in: J. Harrison, J. O'Leary, A. Tolmach (Eds.), 10th International Conference on Interactive Theorem Proving, ITP 2019, September 9-12, 2019, Portland, OR, USA, volume 141 of *LIPIcs*, Schloss Dagstuhl - Leibniz-Zentrum für Informatik, 2019, pp. 28:1–28:21. URL: https://doi.org/10.4230/LIPIcs.ITP.2019.28. doi:10.4230/LIPICS.ITP.2019.28.

[10] T. Nipkow, Programming and proving in Isabelle/HOL, in: Technical report, University of Cambridge, 2013. URL: https://www.cl.cam.ac.uk/research/hvg/Isabelle/dist/Isabelle/doc/prog-prove.pdf.

[11] M. Wenzel, Isabelle/Isar—a generic framework for human-readable proof documents, From Insight to Proof—Festschrift in Honour of Andrzej Trybulec 10 (2007) 277–298.

[12] R. Koenders, F. Wiedijk, H. Geuvers, Intuitionism in Lean (2020).

[13] J. Lupo, cryptolib: Security Proofs in the Lean Theorem Prover (2021). URL: https://project-archive.inf.ed.ac.uk/msc/20215368/msc_proj.pdf.

[14] D. Yamamichi, S. Shigenaka, K. Nakasho, K. Wasaki, A Web Platform for Hosting the Mizar Mathematical Library, in: FMM 2021: Fifth Workshop on Formal Mathematics for Mathematicians, July 30–31, 2021, Timisoara, Romania, volume 3377, CEUR Workshop Proceedings, 2022.

[15] H. Furushima, D. Yamamichi, S. Shigenaka, K. Nakasho, K. Wasaki, An Integrated Web Platform for the Mizar Mathematical Library, in: International Conference on Intelligent

Computer Mathematics, Springer, 2022, pp. 141–146.
[16] K. Nakasho, Y. Shidama, Documentation Generator Focusing on Symbols for the HTML-ized Mizar Library, in: Intelligent Computer Mathematics: International Conference, CICM 2015, Washington, DC, USA, July 13-17, 2015, Proceedings., Springer, 2015, pp. 343–347.
[17] S. Suzuki, M. Nagasaki, K. Nakasho, Classification and Dependency Visualization of the Articles of the Mizar Mathematical Library, in: MathUI 2023: 14th Workshop on Mathematical User Interaction, September 04–08, 2023, Cambridge, UK, 2023.
[18] K. Sugiyama, S. Tagawa, M. Toda, Methods for Visual Understanding of Hierarchical System Structures, IEEE Transactions on Systems, Man, and Cybernetics 11 (1981) 109–125.
[19] J. Urban, P. Rudnicki, G. Sutcliffe, ATP and presentation service for Mizar formalizations, Journal of Automated Reasoning 50 (2013) 229–241.
[20] H. Taniguchi, K. Nakasho, Visual Studio Code Extension and Auto-completion for Mizar Language, in: 2021 Ninth International Symposium on Computing and Networking (CANDAR), IEEE, 2021, pp. 182–188.
[21] G. Bancerek, J. Urban, Integrated Semantic Browsing of the Mizar Mathematical Library for Authoring Mizar Articles, in: Mathematical Knowledge Management: Third International Conference, MKM 2004, Białowieża, Poland, September 19-21, 2004. Proceedings 3, Springer, 2004, pp. 44–57.
[22] H. Miyata, R. Matsumoto, K. Nakasho, VSCode Extension for the Web and Coding Assistance for the Mizar Language, in: MathUI 2023: 14th Workshop on Mathematical User Interaction, September 04–08, 2023, Cambridge, UK, 2023.