SciA11y: Converting Scientific Papers to Accessible HTML

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ABSTRACT

We present SciA11y, a system that renders inaccessible scientific paper PDFs into HTML. SciA11y uses machine learning models to extract and understand the content of scientific PDFs, and reorganizes the resulting paper components into a form that better supports skimming and scanning for blind and low vision (BLV) readers. SciA11y adds navigation features such as tagged headings, a table of contents, and bidirectional links between inline citations and references, which allow readers to resolve citations without losing their context. A set of 1.5 million open access papers are processed and available at https://scia11y.org/. This system is a first step in addressing scientific PDF accessibility, and may significantly improve the experience of paper reading for BLV users.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in accessibility**; **Accessibility systems and tools**; *HCI design and evaluation methods*; *Accessibility design and evaluation methods.*

KEYWORDS

accessibility, accessible reader, scientific documents, blind and low vision users

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1 INTRODUCTION

Scientific papers are primarily available in PDF, a format designed for faithful visual representation that is difficult to make web accessible. Though PDFs can be made accessible,[1] the process is rife with challenges [3]. Though signals suggest that scientific PDF accessibility is improving over time [10, 17], the vast majority of previously and newly published paper PDFs remain inaccessible. For example, Wang et al. [17] find in an analysis of papers sampled across diverse scientific disciplines that only 2.4% of scientific PDFs published since 2010 satisfy five defined accessibility criteria, with only around 15% of papers being properly tagged, and 7% of papers including detectable figure alt-text (though the actual percentage of usable alt-text is much lower).

Science publishers are shifting towards dual publishing or alternate publishing schemes[2] that yield accessible HTML or XML versions of papers in addition to PDF. However,it is unclear how

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[1] https://helpx.adobe.com/acrobat/using/creating-accessible-pdfs.html
[2] The ACM (https://www.acm.org/publications/authors/submissions) and eLife (https://reviewer.elifesciences.org/author-guide/journal-policies) are examples.

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quickly broad adoption will be reached; in the meantime, the significant back catalog of existing research works continues to languish in their inaccessible forms. Tools are available for extracting content from PDFs (e.g. PDF parsers such as pdf2text, pdfalto, PDFBox), converting between document formats (e.g. Pandoc, pdf2html), or making PDFs accessible (e.g. Adobe Acrobat Pro). However, these tools 1) may only extract textual components (in the case of many PDF parsers), 2) may not handle PDFs as input (in the case of Pandoc, which can convert *to* but not *from* PDF), 3) may not produce a satisfactory representation of the scientific document that contains the document's original structural semantics (e.g. most PDF parsers produce a flat stream of tokens and locations as output), or 4) may not do this in an automated fashion (e.g. Adobe Acrobat Pro requires significant manual input to resolve reading order and tag headings and objects appropriately, and is proprietary). In other words, there is currently no suitable system that can understand the content of scientific PDFs en masse and present this content accessibly to users of screen readers.

As an interim solution to this problem, we introduce SciA11y, a system that employs document parsing methods to extract the semantic content of scientific PDFs. The system renders this content in HTML and introduces accessibility features such as navigational headings, tagged objects, table of contents, and within-document navigational links. An example document highlighting various features provided by SciA11y is shown in Figure 1. In this paper, we describe the features available in SciA11y (https://scia11y.org/), and the methods used to produce these features. An intrinsic evaluation of HTML quality revealed that around 86% of papers in our sample had reasonable extractions (good or okay readability per criteria described in Wang et al. [17]), and a preliminary user study with 6 BLV researchers was also positive, with all users stating they would be likely to use the system in the future were it to have high coverage of papers. We refer readers to Wang et al. [17] for further details on evaluation.

2 THE SCIA11Y DEMO

A demo of SciA11y is available at https://scia11y.org/. We process 1.5 million open access scientific PDFs using our pipeline and make these available in the demo. Processing steps for deriving a document with improved logical reading order are described in Section 2.1 and the addition of navigational features are described in Section 2.2.

2.1 Inferring logical reading order

SciA11y integrates the output of two scientific PDF extraction systems: S2ORC [11] (which leverages Grobid [12] to process PDFs) and DeepFigures [15], to identify and extract textual elements and figure/table elements respectively. The Grobid PDF processing library [12] generates an XML representation of the document content with labeled text spans corresponding to metadata fields like title, authors, affiliation, and venue; textual fields like section headings, body text paragraphs, and figure and table captions; and bibliographic fields like reference entries. S2ORC [11] then implements additional logic to improve the accuracy of Grobid output and merge this output with metadata from the Semantic Scholar literature corpus.[3] For figure/table elements, we employ DeepFigures [15], which identifies bounding boxes for figures and tables in scientific PDFs and extracts these as images along with their caption text.

We combine textual elements from S2ORC and figure/table elements from DeepFigures to create the HTML representation. We attempt to preserve the logical reading order intended by the authors. To do this, we begin with metadata fields like title, author, and abstract, followed by paragraphs organized under section headings, placed in intended reading order based on columnar organization, and finally, the references section with itemized bibliography entries. Figures and tables are inserted at paragraph breaks immediately following their first mention (heuristically detected). The logical order of figures and tables is also preserved, i.e., if "Figure 2" is mentioned in text before "Figure 1", we insert Figure 1 before Figure 2 immediately following this paragraph.

2.2 Navigation features

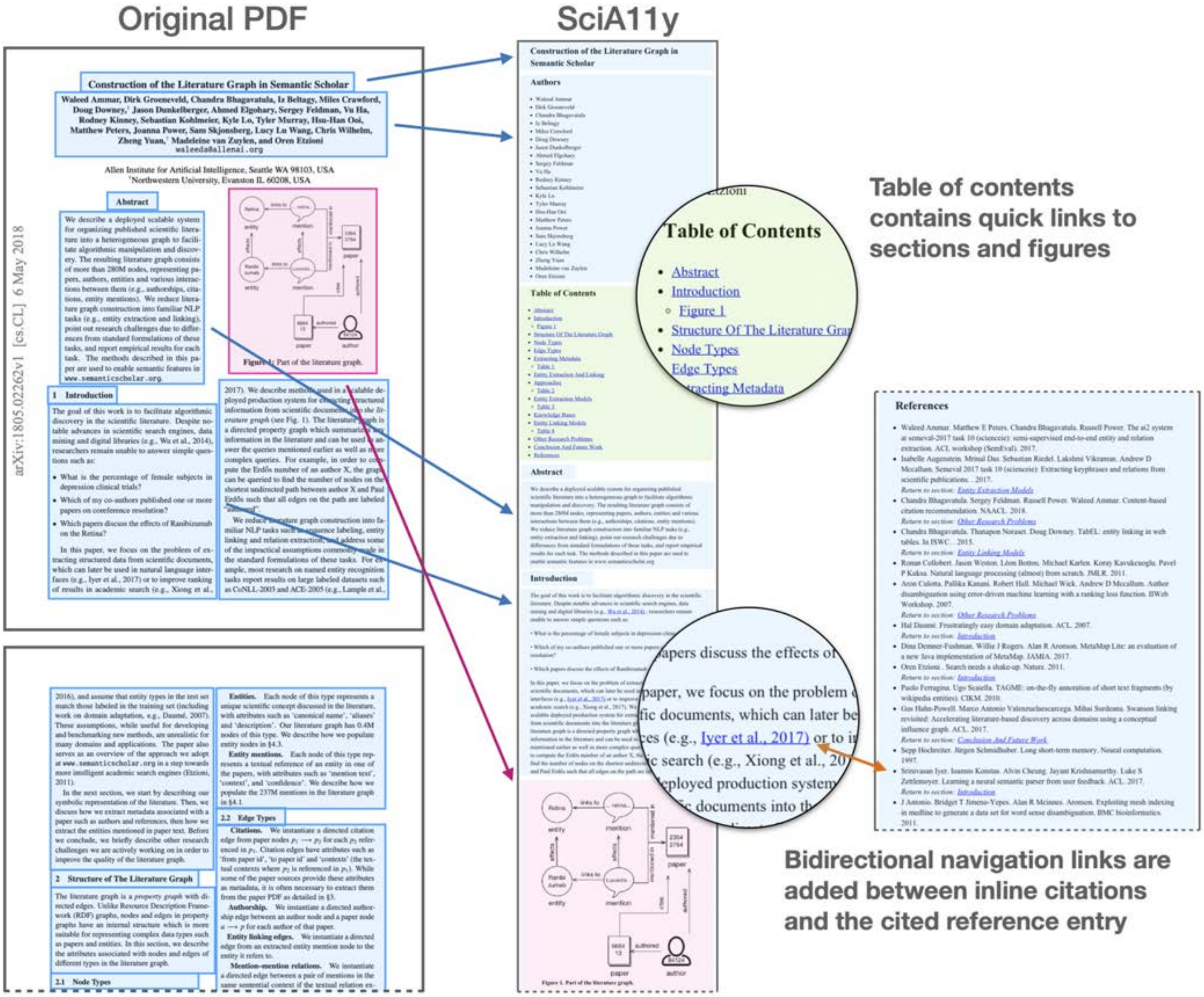
To the basic document structure, we add navigational features, focusing on features to support skimming and scanning for users of screen readers (examples shown in Figure 1). We add a table of contents near the beginning of the document, with links resolving to all section headers as well as figures and tables nested under these headers. This exposes users to the overall structure of the paper, and allows readers to more quickly skip to intended sections. We also insert bidirectional links between inline citations and the cited reference entry in the bibliography. When multiple inline citations exist for the same reference entry, multiple back links are provided to the first occurrence of the citation in each section of the paper. This allows the user to resolve an inline citation and return to their original reading context with minimal key strokes.

3 SUMMARY

Scientific PDFs are difficult to make accessible for screen readers, and most paper PDFs are consequently inaccessible and difficult to navigate. We propose and demonstrate a pipeline for extracting the semantic content of paper PDFs and rendering this content as an accessible HTML document. Our hope is that this system and framework resolves some of the challenges of reading papers using screen readers, and can be a starting platform for further improvements. Both an intrinsic and preliminary user evaluation of the system had positive results (see Wang et al. [17] for details). In a user study conducted with 6 BLV researchers who primarily engage with scientific papers using screen readers, all users responded positively to our introduced navigation features, as they simplified skimming the document and navigating to specific sections. All users said that they would be likely to use the system in the future if available, indicating a need for systems like SciA11y. The user studies also revealed a host of other challenges, such as difficulties accessing the content of figures, tables, and math equations, which pave the way for future work in this direction.

The current iteration of SciA11y focuses on improving screen reader accessibility in terms of navigation within the HTML document. To build upon this framework, we intend to improve PDF

[3] https://semanticscholar.org/


Original PDF
SciA11y
Table of contents contains quick links to sections and figures
Bidirectional navigation links are added between inline citations and the cited reference entry
arXiv:1805.02262v1 [cs.CL] 6 May 2018
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fic documents, which can later be
ces (e.g., Iyer et al., 2017) or to i
c search (e.g., Xiong et al., 20
eployed production system
c documents into th

Construction of the Literature Graph in Semantic Scholar

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Abstract

We describe a deployed scalable system for organizing published scientific literature into a heterogeneous graph to facilitate algorithmic manipulation and discovery. The resulting literature graph consists of more than 280M nodes, representing papers, authors, entities and various interactions between them (e.g., authorships, citations, entity mentions). We reduce literature graph construction into familiar NLP tasks (e.g., entity extraction and linking), point out research challenges due to differences from standard formulations of these tasks, and report empirical results for each task. The methods described in this paper are used to enable semantic features in www.semanticscholar.org.

Figure 1: Part of the literature graph.

1 Introduction

The goal of this work is to facilitate algorithmic discovery in the scientific literature. Despite notable advances in scientific search engines, data mining and digital libraries (e.g., Wu et al., 2014), researchers remain unable to answer simple questions such as:

- What is the percentage of female subjects in depression clinical trials?

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Figure 1: SciA11y converts PDF to HTML, introducing navigation features such as a table of contents and links between inline citations and cited reference entries. An example of several pages of Ammar et al. [1] rendered into HTML by SciA11y.

extraction, e.g., by adopting better scientific document understanding models like those proposed in Shen et al. [14], and provide better representations of paper elements like figures, tables, and equations. For example, we intend to integrate features for reading graphs and charts [4–6], mathematical equations [2, 7, 13, 16], and further processing table images into HTML [8, 18, 19]. Regarding figures specifically, the vast majority of figures from scientific papers lack alt-text, and methods for inferring or generating alt-text could improve current screen reader user experience when reading figures. As for UI/UX considerations, interactions such as those proposed in Head et al. [9] may allow us to provide additional information at the point of interest (surfacing bibliography entries at the inline citation rather than navigating away), further reducing loss of reading context, though the accessibility of these interactions for users of screen readers must be explored independently.

In summary, we introduce the SciA11y system for rendering scientific PDFs as HTML, which can increase the accessibility of these documents for screen readers. A set of 1.5 million open access papers are available to read in HTML format at our demo site: https://scia11y.org/.

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