

# Multimedia E-Books for Digital Mechanism and Gear Library

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**Abstract**— This paper presents a digital engineering library – the Digital Mechanism and Gear Library, DMG-Lib – providing a multimedia collection of e-books, pictures, videos and animations in the domain of mechanisms and machines. The specific characteristic about DMG-Lib is the enrichment and cross-linking of the different sources. DMG-Lib e-books not only present pages as pixel images but also selected figures augmented with interactive animations. The presentation of animations in e-books increases the clearness of the information.

To present the multimedia e-books and make them available in the DMG-Lib internet portal a special e-book reader called StreamBook was developed for optimal presentation of digitized books and to enable reading the e-books as well as working efficiently and individually with the enriched information. The objective is to support different user tasks ranging from information retrieval to development and design of mechanisms.

**Keywords**— E-books, digital library, multimedia, enrichment and cross-linking

## I. INTRODUCTION

Digital libraries around the world are many and varied. The growth in digital libraries including collections of e-books, pictures, audio and video sequences has been phenomenal in recent years [1]. Digital libraries in practice very often include multimedia content but just a few try to link and enrich the documents in order to support information retrieval and users' orientation in the multimedia information space.

Typical investigations in user interface design and usability for digital libraries look at supporting users in searching and browsing for information. Much less attention has been paid to presentation, enrichment and cross-linking of multimedia documents and e-books and the users' needs and tasks while working with heterogeneous, digitized content.

In case of e-books for example most collections offer page images rather than electronic text. If the worst comes to the worst the users have to use vertical and horizontal scrollbars

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because they want to display the scanned pages at an easily readable size (see Figure 1).



Fig. 1 E-book of Göttinger Gutenberg-Bibel [2]

Other e-book projects present 3D virtual books that look and feel somewhat similar to its physical correspondent [3]. Whether this format increases the readability and supports sense making is still not proven.

Noting this, we developed an e-book reader for a digital engineering library – the Digital Mechanism and Gear Library – that presents multimedia e-books (pages cross-linked and enriched with pictures, videos or animations) and offers different tools to easily work with the information like bookmarks, annotations and animation player.

## II. DIGITAL MECHANISM AND GEAR LIBRARY

The Digital Mechanism and Gear Library (DMG-Lib) is a digital engineering library with the objective of collection, integration, preservation, systematization and adequate presentation of information in the field of mechanism and machine science. This does not only include the presentation of text documents and pictures but also the presentation of physical models. These physical models are used to illustrate and visualize kinematic basics and methods and serve as a basis for mechanical designers looking for a solution to their motion tasks in different machinery such as packaging or processing machines. Large collections of these physical models exist worldwide spanning a wide arch from historic models showing e.g. sewing machines from the late 19th century, typewriters from the early 20th century and acrylic glass models still used today in university lectures where they

are placed on the overhead projector (see Figure 2).



Fig. 2 Physical mechanism model digitized for DMG-Lib

The systematic analysis of mechanisms and machines started already in the 19th century, primarily in Europe. Particularly important are for example the theoretic and practical works of the engineer F. Reuleaux, who described more than 1000 mechanisms in detail [4] and set up an internationally acknowledged collection of more than 800 physical models. Mechanism and machine science today is still essential for industry and it will become even more important due to the introduction of new technologies like robotics and corresponding new fields of application.

But the worldwide information about mechanisms and machines is mostly scattered, difficult to access and does not comply with today's requirements concerning a rapid information retrieval. The available technical literature (science books, scientific journals, mechanism catalogues and congress proceedings) often is no longer adequate according to today's requirements regarding content and media presentation and the large collections of physical models are kept under lock and key in universities or museums. Existing activities to provide such variety of information about mechanisms and machines via internet are promising (e.g. [5]) but by far insufficient. The most important problems are:

- The amount of information originating from different sources like books, technical reports, physical models or mechanical drawings.
- The efficiency to retrieve and work with this information. Even though digitizing and internet based presentation already eases the access towards certain documents, a proactive, user oriented and efficient solution retrieval for given engineering tasks is not yet fully accomplished in existing technical data bases. More than just a collection of digitized documents or links to relevant internet pages must be offered in order to fulfil such requirements.

The DMG-Lib is digitizing the different information sources, adding metadata and enriching information by cross-linking and provision of different description levels (textual descriptions of use and benefit, images, animations) so that this still important knowledge becomes again accessible for the public (see Figure 3).

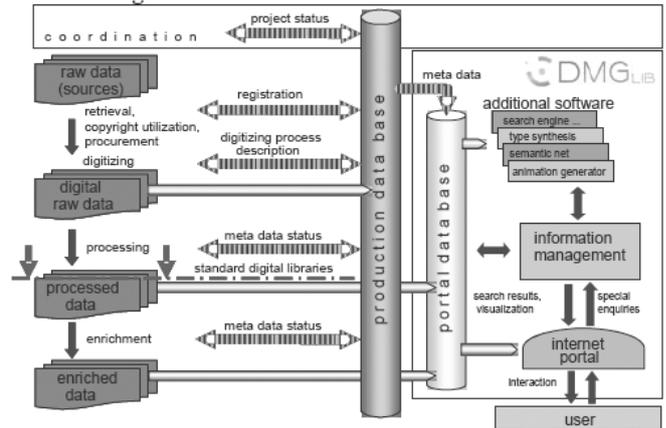


Fig. 3 Concept of data processing for DMG-Lib distinguished from other digitization projects because of the step “enrichment”

In order to meet the users' needs the digital library design is based on the requirements and tasks of different user groups like engineers, scientists, teachers, students, librarians, historians and others. The main objective is aiding the mechanism designer when developing solutions for given motion tasks. Figure 4 shows the different steps that have to be taken during the design of a mechanism together with the results that can be achieved for each step. The main topic is the type synthesis of mechanisms [6] and therefore the DMG-Lib offers a collection of mechanism descriptions and solution principles taken from the large number of mechanism models. With the DMG-Lib the knowledge relevant for the development and design of mechanisms can be displayed in different forms such as plain text, pictures, animations and interactive elements by using internet functionalities.

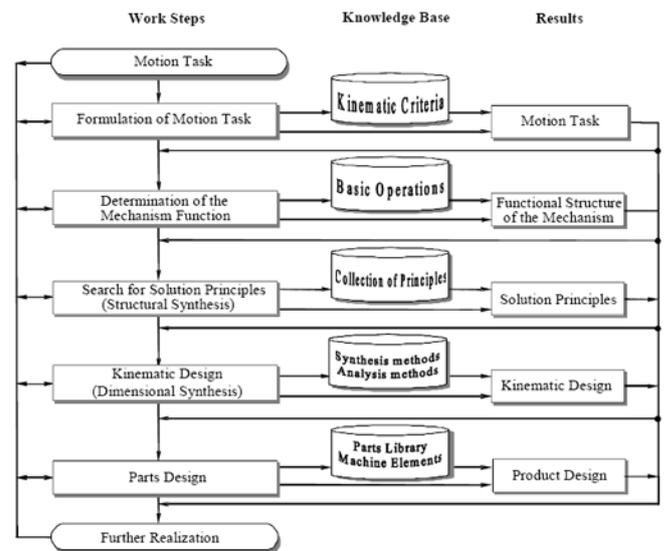


Fig. 4 Workflow for the mechanism design

### III. MULTIMEDIA LIBRARY COLLECTION

The DMG-Lib concept and workflow takes into account that technical knowledge exists among others in the form of texts, images and physical models (see Figure 5).

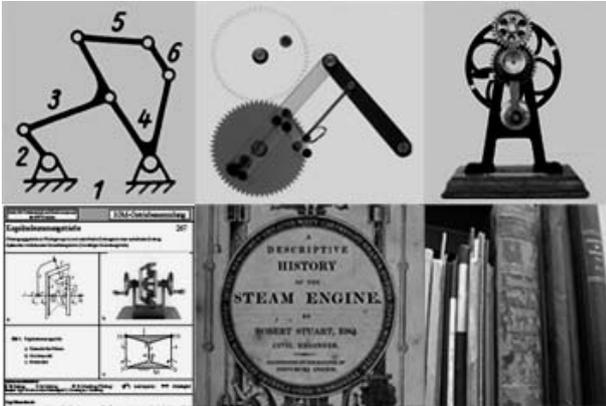


Fig. 5 Some examples of different information sources digitized for the DMG-Lib multimedia library collection

The engineering sciences require analytic, graphic and physical forms of representation. This applies especially to the mechanism theory, which primarily uses geometric approaches for the solution of problems. Therefore, graphic or physical representations are indispensable. Because the clearness of graphic descriptions e.g. in form of mechanical drawings or photos is limited in some cases, videos or animations may lead to an improved comprehension.

The focus is not only on textual documents, images and animations. Thousands of unique physical models exist, which have no or only very limited access for the public. These functional models are also digitized and available as videos and animations.

To offer users a wide variety of opportunities for retrieval and utilization the digitized sources are extensively post-processed and enriched as well as cross-linked with various information e.g. animations, metadata, references and constraint based models. This huge amount of available heterogeneous information sources in the DMG-Lib implies the key challenges of this project:

- Implementation of an efficient, uniform and user-centered information retrieval [7], [8]
- Specific forms of information visualization for text, still and moving images
- Specific concepts to enrich and cross-link the information
- Adequate tools to work with the information presented in the internet portal [www.dmg-lib.org](http://www.dmg-lib.org).

### IV. LIBRARY VISUALIZATION TOOLS

The Digital Mechanism and Gear Library is a heterogeneous digital library with regard to the sources and library collection. 1680 e-books, 962 pictures, 522 videos/animations are available in the DMG-Lib in April 2008 and the collection is still growing. This results among other fields

in the need for specific tools for representation of the different multimedia formats. A special player to present the videos and interactive animations of mechanisms and machines is implemented in the internet portal as Java Applet (see Figure 6).



Fig. 6 Physical model digitized and available as video and animation in the DMG-Lib internet portal [www.dmg-lib.org](http://www.dmg-lib.org) (left), picture gallery to support visual image retrieval (right)

To enable an easy form of image retrieval picture galleries consisting of photos, drawings, slides and extracted figures out of books support browsing for information (see Figure 6). In order to present the e-books a document viewer called StreamBook was developed (see Figure 8). The DMG-Lib e-books are presented in form of scanned pages but are available as full-text documents because of optical character recognition [9].

However, the different multimedia information should not exist next to each other without any relations. For the enrichment of the scanned documents an animation generator was developed which allows the simulation and the variation of drawings, images and models in an easy and fast way [10]. The results are e-book pages with animated figures visualizing the motion behavior of a mechanism. This is especially important for users searching for solution principles because they can easily understand the complex mechanism. Nevertheless figures and text can be cross-linked to other digital objects of library collection. All this allows a target oriented and efficient dynamic access to the contents of DMG-Lib. DMG-Lib multimedia e-books can be displayed with the help of StreamBook presented in the following.

### V. ENRICHED MULTIMEDIA E-BOOKS

#### A. Text documents in the field of mechanism and machine science

Typically text documents in the field of mechanisms and machine science are containing many figures. Especially old books are presenting figures not within the text but as a collection at the end of the book referenced in the text.

To better understand the motion of figured mechanisms and machines DMG-Lib can animate selected figures. These animations are augmenting original figures and can easily be displayed in the e-book pages with an integrated Java Applet (see Fig. 7).

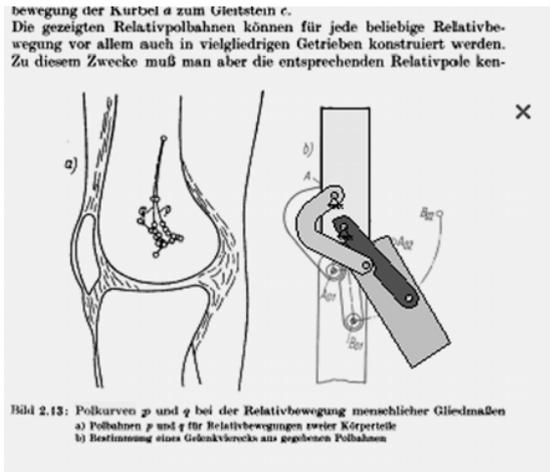


Fig. 7 DMG-Lib e-book page: the figure on the right sight is overlaid by an interactive animation to show the mechanism's motion behaviour

With special analyzing tools the pages' structures are recognized so that cross-linking from text to figures at the end of the e-book is possible. But DMG-Lib e-books not only offer cross-linking within an e-book, cross-linking from text or figures on pages to other digital library objects are another feature of StreamBook.

**B. User Tasks and system requirements**

Working with e-books is more than turning pages. The DMG-Lib users expect tools for

- zooming to easily adapt the pages' size for optimal reading
- searching within the full-text
- personalization like annotations, bookmarks or drawing tools and
- displaying augmented or cross-linked multimedia content like pictures, videos or animations to analyze and better understand the motion behavior.

Concerning the system requirements the users don't want to install any plug-ins before using the DMG-Lib e-books. Therefore the StreamBook is developed as browser application with the help of AJAX (Asynchronous JavaScript and XML) and any user with an Internet Explorer, Firefox or Opera Browser can immediately read the e-books with out any software installation. The web browser becomes simultaneously an e-book reader. To display the interactive animations the installation of Java Runtime Environment (JRE) is necessary but this is done within a few minutes and many users still have installed this software package.

**VI. STREAMBOOK - CONCEPT AND FEATURES**

**A. Navigation and visualization**

To allow users individual working with e-books there are different navigation tools. Pages can be turned by clicking buttons, by turning mouse-wheel or by direct manipulation with drag & drop. Jumping to selected pages can be done by entering the page number into an input field or by using the

page history listing all viewed pages. To fit the page for optimal reading users can zoom in different levels or fit the page to height or width of screen. Full-screen mode fades out the horizontal digital library navigation bar for optimal presentation with regard to resolution. Because text documents in the field of mechanisms and machine science are rich in figures, diagrams, formulas or tables StreamBook also implements an overview & detail interface by providing a right navigation panel with thumbnails of each of the pages and the full-size page in the center of the screen. This is very useful for quick overview and visual searching and is based on the metaphor to thumb through a physical book.

**B. Enrichment and cross-linking**

Selected figures in DMG-Lib e-books can be overlaid by interactive animations showing the motion sequences of mechanisms and machines. User can display and play these animations just with two clicks and above all easily interact with animations by direct manipulation to control the speed and direction of motion (see Fig. 8). This interactive presentation together with the text information is helping engineers to easily understand the mechanisms' motion behavior, to perform analysis and synthesis methods (see Figure 4) and to make a quick decision if the information is relevant. If the user is zooming into the page the animation is adapted automatically to zoom level.

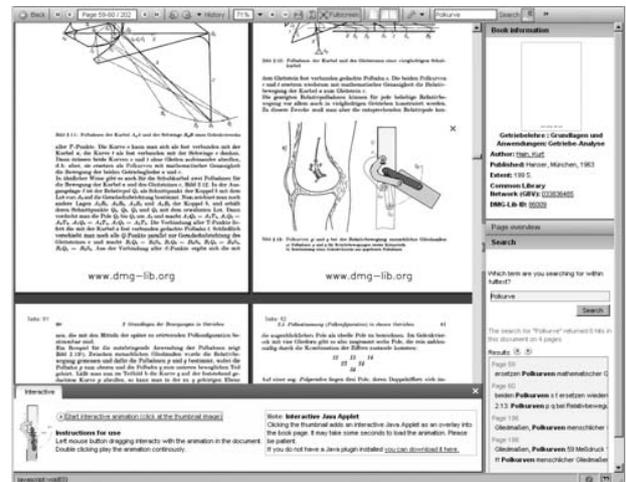


Fig. 8 StreamBook: reader for DMG-Lib multimedia e-books showing page with a figure enriched with interactive animation (available online <http://www.dmg-lib.org/dmglib/handler?docum=790009>)

Because DMG-Lib is analyzing the page structure and detects the coordination of each single word highlighting of hits of full-text retrieval in the pixel image and cross-linking within the e-book, to DMG-Lib glossary or to other digital library objects is possible.

**C. Full-text retrieval**

Searchability is a big advantage of e-books compared to print publications. Because of OCR (optical character recognition) and the search engine Lucene full-text retrieval in

DMG-Lib e-books can be used. The hits are highlighted within the text as well as listed within a preview text passage at the right panel so that the users can easily find the required information.

#### D. Personalization

Tools for personalization increase the added value of StreamBook because user can work with the e-books according to their individual needs. Bookmarking pages and editing individual notes for annotation can support users in structuring the e-books and they can easily relocate identified information.

### VII. CONCLUSION

DMG-Lib allows worldwide access to information about mechanisms and machines presented in a new and innovative form. With the unique process of digitization, enrichment and cross-linking of information DMG-Lib is intended to support research and development projects, enable reuse of existing solutions for new mechanism and machine designs and present new ways and means for private study and patent research. The multimedia e-books are good examples how a transition from a static to a dynamic and problem oriented presentation of information can be achieved.

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