

The Digital Mechanism and Gear Library supports design engineers in finding ideas for design solutions in the field of motion systems

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Abstract

This paper presents how the “Digital Mechanism and Gear Library” (DMG-Lib) can support design engineers in their daily work. Selected case scenarios of typical engineering tasks and their solution supported by the DMG-Lib are demonstrated.

The DMG-Lib is a digital, internet-based library (www.dmg-lib.org) with the objective of collection, integration, preservation, systematization and adequate online presentation of information in the field of mechanism and machine science. The DMG-Lib offers users a wide variety of opportunities for retrieval in heterogeneous information sources and media types. The digitized content sources are extensively post-processed and enriched with additional information as well as cross-linked with various information. Supplemented with innovative multimedia applications and a semantic information retrieval environment, the DMG-Lib provides an efficient access to this knowledge space not only for engineers but also for students, teachers, historians or other technical interested persons.

KEY WORDS: *digital library, information retrieval, knowledge data base, mechanisms, kinematics.*

1. Introduction

Motion systems are important parts of technical products which are often composed of mechanisms and gears. Today mechanism and gear technology is essential for the whole industry and it will become even more important due to the introduction of new technologies and respective new fields of applications. However, the existing theoretical and practical knowledge about mechanisms and gears is scattered worldwide in literature, photographs, solid functional demonstration models, technical drawings etc., and is only fragmentarily accessible. This does not comply with today’s requirements concerning a rapid information retrieval. However, design engineers demand an efficient access to the whole knowledge of the mechanism theory. The preservation of knowledge and didactic experiences in mechanism theory is also important, because e.g. education material often gets lost when lecturers retire. Old and unique literature and physical models with only a few of them left are quite difficult to be accessed. A solution for this can be the collection and presentation of as much as possible relevant information resources in the field of mechanism and gear science in a centralized, worldwide accessible online platform.

There are a few projects that collect and present knowledge in the field of motion science using a web based library. Noteworthy among them are KMODDL, a kinematic model collection of the Cornell University Library [1], the Taiwanese Collection of Educational Models [2], the Model Collection of the Moscow State Technical University [3], and the Mechanism Collection of the RWTH Aachen [4]. Additionally there is a lot of smaller projects e. g. the project "Leonardo da Vinci" from the University of Applied Sciences Bielefeld [5]. But all these collections represents often their own content only and mostly they set their focus on one content type only, e.g. physical models or drawings.

Therefore, the development of the worldwide accessible “Digital Mechanism and Gear Library” (DMG-Lib, www.dmg-lib.org) [6, 7] was started as an interdisciplinary project involving different departments of Ilmenau and Dresden Universities of Technology and the RWTH Aachen in 2004. The DMG-Lib aims at the collection, systematization and adequate presentation of the worldwide knowledge in the field of mechanism and gear science. Currently, the DMG-Lib database holds more than 56.000 records (Feb. 2013). To offer users a wide variety of opportunities for retrieval and use, the digitized resources are extensively post-processed and enriched with various information like animations, metadata, references and constraint based models. The focus is not only on textual documents and images, but also on digitalized functional models which are represented as videos and interactive animations. Thousands of such unique models exist, with no or only very limited access for the public. This huge amount of available heterogeneous information resources in the DMG-Lib combined with innovative multimedia applications and a semantic information retrieval environment implies a key challenge of this project: the implementation of an efficient, uniform and user-satisfying information retrieval.

In 2010 the DMG-Lib consortium was expanded by partners from France, Spain, Romania and Italy within the European project “thinkMOTION – DMG-Lib goes Europeana” [8], which is the successful continuation of the German DMG-Lib project at European level. The thinkMOTION project establishes the DMG-Lib as a new content provider for Europeana, a newly founded European online library portal [9]. The objective of the thinkMOTION project respectively to the Europeana project is the preservation of a variety of technical historical and today’s content reflecting the rich

European heritage concerning motion systems. With the thinkMOTION project, the number of content available in the DMG-Lib increased significantly and is still increasing. In this way, the thinkMOTION project makes a contribution to increase the number of offered content in the technical field within the Europeana portal. Furthermore, the DMG-Lib portal navigation are now available in up to six languages (English, Italian, French, Spanish, Romanian, and German) which allow a new quality for both easy and extensive access to multilingual content. By providing the DMG-Lib online portal in various languages and by its connection to the Europeana portal, it is possible to address more people in Europe and in the world than ever before.

2. User groups of the DMG-Lib

The DMG-lib provides access to the mechanism and gear technology for different user groups with specific requirements each on the design of the online portal. According to the Usability Engineering Lifecycle developed by Deborah J. Mayhew [10] a requirement analysis including expert interviews and user focus groups has been carried out to get to know the users as well as their tasks, goals and needs to ensure an efficient, effective and custom-tailored access to the information stored within the DMG-Lib.

In a first step, a project internal expert round with representatives from the field of mechanism and gear science proposed five main user groups: students of mechanism design, teachers and researchers, university design engineers, free enterprise engineers, and patent engineers. Five focus groups, one per user group, with a total of 29 participants provided qualitative data regarding the user's characteristics, tasks and goals of their daily work, as well as their expectations and wishes. As a result of this analysis, concrete user profiles describing the user groups were derived, which built the basis for the functions and possibilities implemented in the DMG-Lib portal. For example, engineers are usually looking for design solutions, detailed structural and functional descriptions or adequate technical terms, researchers are often retrieving for literature, and students are mostly looking for teaching materials or expect a comprehensible introduction to the subject [11].

The DMG-Lib is designed to satisfy the requirements of different user groups like engineers, scientists, teachers, students, librarians, historians and other technical interested persons. Exemplarily for the user group of design engineers, various application scenarios that show how the DMG-Lib can support design engineers in their daily work are described below.

3. How can the DMG-Lib support the user group of design engineers in their daily work

In publications of design methodology is estimate that approximately 20 percent of the design engineers' working time is consumed by searching for information [12]. In this context, using modern information and communication technologies and online available repositories and libraries for getting information will be more and more important for shaping an effective design process. Four selected case scenarios of typical engineering tasks and their solution supported by the DMG-Lib are described in the sections below and range from getting a general overview on a topic to finding a solution for a given motion task.

3.1. Getting an general overview on a topic

For a lot of people as well as for design engineers it is often important to delve into a new subject in their profession. The DMG-Lib can support design engineers to do this in the field of mechanism science by providing of suitable content. In the DMG-Lib, the engineer has access to a variety of heterogeneous content sources, which ranges from technical books, journal articles, research reports, mechanism catalogues, and technical drawings over physical demonstration models, photographs, movies, interactive animations to software tools.

To get a general overview on a topic, a simple or an advanced search mask (Fig. 1) can be used to find relevant content in the DMG-Lib portal. By this means, the engineer can search for a topic in the titles or in the full text of the literature documents or content meta data descriptions. Combinations of more than one search words by logical operations can be used by the advanced options menu. This search delivers a list of results with an icon which represents the kind of content (literature, image, video, interactive animation, biography, mechanism description etc.) and with a thumbnail image as well as a short description of the content (Fig. 2). Alternatively, the thumbnail images can be displayed in a gallery view mode for a better overview (Fig. 4).

Based on this result list, pages with detailed descriptions, all descriptive metadata and several links to additional content are cross-linked from each search result hit. So the user can find out authors, who concentrate on this specific topic and can get a list of other publications of these authors. Furthermore the engineer gets additional information about a selected author, his profession and his work and he can get a first impression of the expertise of this author and therefore of the relevance of his publications on the related topic.

In this way the engineer can become an overview on a topic or he can become more and more detailed information about this theme and related ones. So the engineer can read relevant pages in books and articles and can jump directly to the pages where the topic is described and the search terms are highlighted (Fig. 3).

Fig. 1 Mask for a general advanced search

Fig. 2 Search results in the list view mode with short descriptions of the content and a list of content type categories for filtering search result to reduce the number of hits

Fig. 3 Using full-text search with a to-the-point search result visualization and text highlighting for finding information. A link list at the right side gives directly access to the text passages which contain the searched topic

3.2. Search for an explanation of a specific technical term or for a specific mechanism

If a design engineer encounters an unknown technical term from the field of motion systems, e. g. while reading a publication or a manual or analysing the design of a mechanical device or machine, he can search for an explanation of this term in the DMG-Lib. By using the full text search, he can find pages in books or articles which define or explain this term. For an efficient work, the search terms are highlighted on the publication's page and are listed in a cross-linked bookmark list inside the book reader (Fig. 3). Photographs or figures from literature, which illustrates the term, can also be found by the text search masks.

Many publications or catalogues contain representations of mechanisms in form of technical drawings, solution principles or photographs. These mechanisms extracted from scanned or digital sources or taken as image sequences from physical models, form together with mechanism-specific metadata so-called mechanism descriptions inside the DMG-Lib.

To get information about a specific mechanism, additionally to passages in literature, a lot of these mechanism descriptions are available in the database. Enhanced with additional sources such as interactive animations, videos, images or hyperlinks to relevant pages in literature, the collection of these mechanism descriptions provides in combination with mechanism-specific search functions, described in section 3.4, a powerful knowledge base for design solutions in the field of mechanical motion systems. The interactive animations or the videos provide a visual impression of the certain motion-characteristic.

In selected textbooks the solution principle of chosen figures of mechanisms are animated in an overlay mode inside the book page. While reading the text of the book, the engineer can simultaneously interact with the animation to get a better understanding of the mechanism.

3.3. DMG-Lib as a source of inspiration for solution approaches or ideas

If the design engineer has no clear idea how the solution can look like at the beginning of his work on a design task, looking through existing solutions and examples of application can be a good way to find an idea or an approach to a solution.

Our project partners reported about persons who are standing in front of the physical mechanism collections in the public areas of their institutions with a writing pad for hours. These persons looked through the collections to find an idea for the solution for their motion task. But in this way, these persons have only access to a very small public available part of the whole amount of physical demonstration models of one institute at the same time.

In the DMG-Lib, in contrast, the design engineer has access to a huge pool of solutions. He can access to a lot of physical demonstration models of various institutions at the same time as well as of mechanisms from figures of literature, photographs, videos or animations.

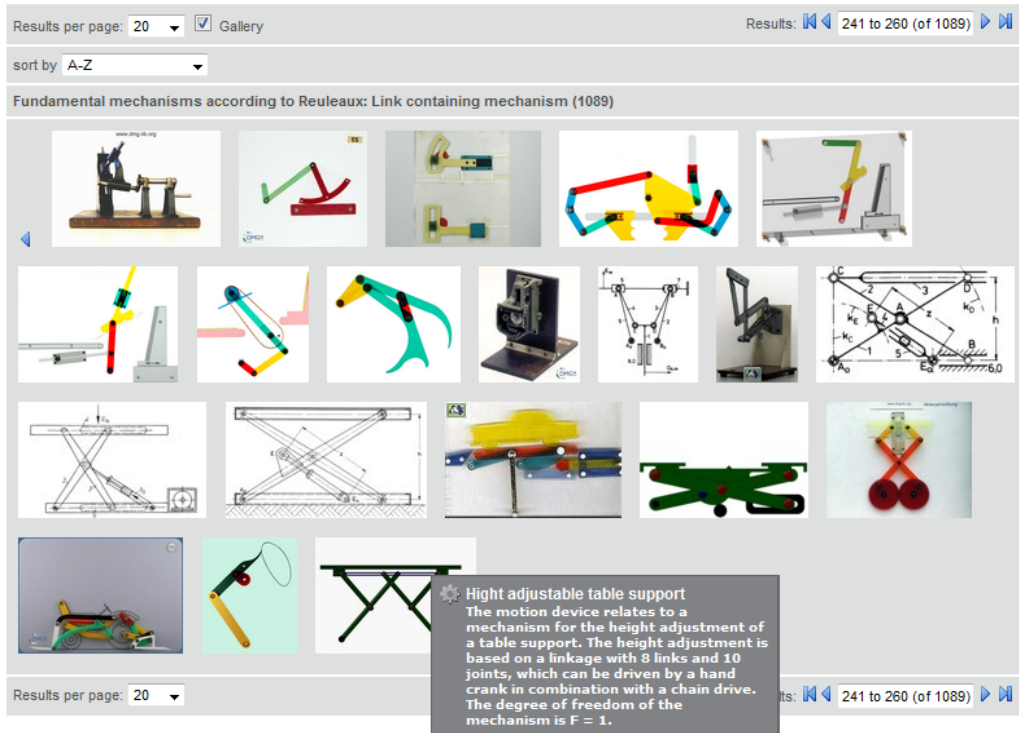


Fig. 4 Browsing through collections of physical demonstration models and images of mechanisms from literature in the gallery view mode - additional information are displayed by moving the mouse pointer over a thumbnail image

For a better clarity, the user can reduce the amount of displayed solutions by setting of constraints such as application fields (e. g. transportation, agriculture, medical technology etc.) or contained fundamental mechanisms (e. g. cam-, gear-, belt-mechanism etc.).

A gallery view mode allows the user to browse through the mechanism thumbnail images and to make a first inspection and a preselection of the solutions. By moving the mouse pointer over the thumbnail images of a solution, the title and a short description of the mechanism will be displayed (Fig. 4).

In this way of using the DMG-Lib, design engineers can find inspiration in solution examples and their descriptions and that can help him to complete his design task.

3.4. Search for a solution of a specific design task

Design engineers are searching regularly for mechanism structures that comply with essential parameters of a design task. Therefore, the search interface shall be broad in scope and the different search criteria shall be entered simultaneously and independently from each other. To meet these requirements, the DMG-Lib provides a special mechanism search module with a structured search form, where the motion task can be described explicitly with controlled, partially icon-based vocabulary.

For easy use, the search form is divided into structural and motion related criteria, which allow the input of free strings for the mechanism title or pre-selected attributes of the mechanism behavior. At first, the motion task must be classified. Therefore the user can assign his problem to typical subtasks. The "Topology of mechanism" form sheet (Fig. 5) contains the basic functions of the mechanism. The kind and number of inputs, the type of contained fundamental mechanisms or the maximum number of links are a few possible requirements that can be set here. The form sheets for the sub-tasks "Guidance function" and "Transfer function" (Fig. 6) can be selected depending on the intended application of the searched mechanism. These mechanism specific metadata for which can be searched for in the DMG-Lib are based on a doctoral thesis [13].

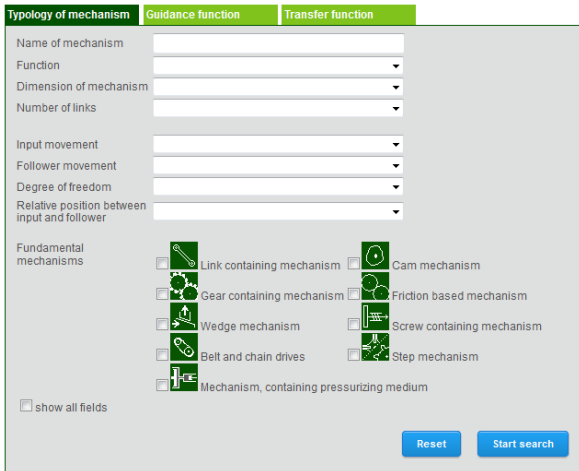


Fig. 5 Specific mechanism search form for the topology of a mechanism

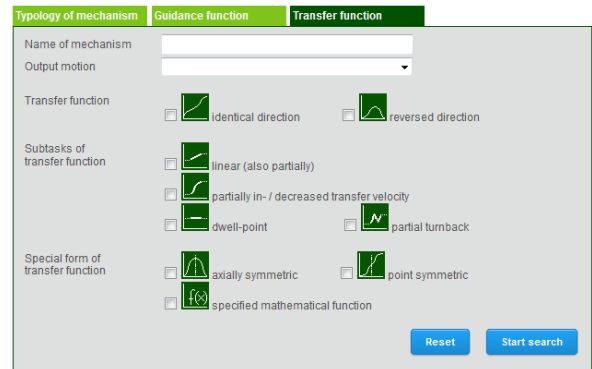
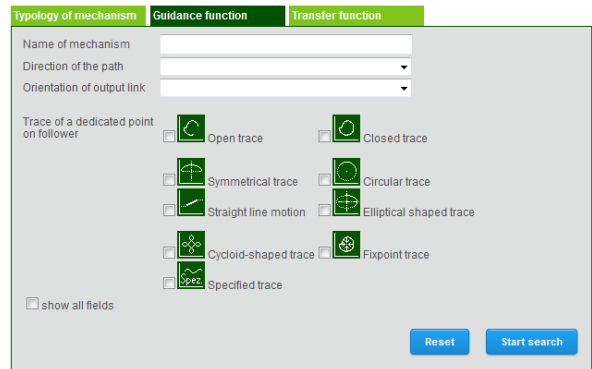


Fig. 6 Specific mechanism search forms for the guidance and the transfer function of a mechanism

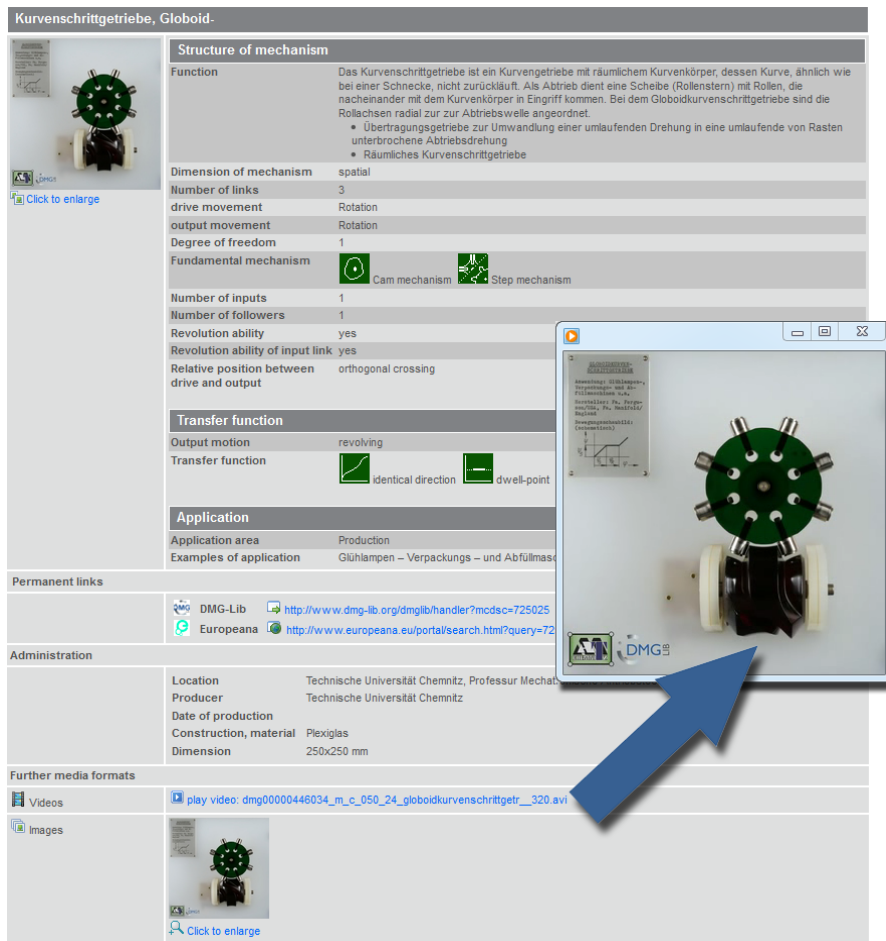


Fig. 7 Detailed view of a mechanism description and a started video of a physical demonstration model

After submitting the query formulated within the selected search form, a list of mechanisms is generated, displaying all mechanisms matching the specified criteria. For each search result hit a tabularly formatted page with a thumbnail image, a brief functional description and the most essential topological information are displayed (Fig. 7). This can be used as starting point for a more refined, secondary search with additional or slightly varied parameters. In this way, the design engineer can reduce the solution field iteratively. Due to the large amount of existing motion tasks, the DMG-Lib can often provide only a principle solution which realizes the desired motion approximately only. But such a principle solution can be the base for further synthesis steps.

4. Conclusion

The scenarios, described above, are exemplarily and not the only possible ones that are imaginable for the working of a design engineer with the DMG-Lib. The use of the search functions and of the representations of the search results is not fixed assigned to an individual scenario and also the work of a design engineer can often not exactly assign to the described scenarios. Therefore, the search functions are often used in combination or alternately.

The Digital Mechanism and Gear Library is currently the largest via Internet available digital library in the domain of mechanism and machine science. According to fundamental design methodology, this library can be instrumental in the process of designing motion devices and solving motion tasks by using mechanical solutions. It can be a very helpful tool in the everyday work of engineers, scientists and students. Furthermore, the DMG-Lib can help young people to discover their interests in mechanical engineering and can also be interested for historians and for technically enthusiastic people.

Due to its different approaches in providing information, DMG-Lib is a versatile and a fast accessible information resource to refresh personal knowledge about engineering techniques and specific analysis and synthesis methods. The collection of mechanism descriptions inside the DMG-Lib is one of the most comprehensive repositories in the world which is providing searchable descriptive metadata, interactive animations of mechanisms and linked additional information. In contrast to other digital repositories in this field, unique features of the DMG-Lib are the large number of heterogeneous content sources in combination with the mechanism specific metadata, a powerful result oriented search functionality, and a well-structured and customizable representation of the search results.

The future scope of the DMG-Lib project is to increase the amount of available documents by a global orientation, to improve continuously the used technologies or tools, and to establish an international community of contributors sharing their knowledge to each other.

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