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Experimental DML over digital repositories in Japan

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Abstract. In this paper the authors show an overview of Virtual Digital Mathematics Library in Japan (DML-JP), contents of which consist of metadata harvested from institutional repositories in Japan and digital repositories in the world. DML-JP is, in a sense, a subject specific repository which collaborate with various digital repositories. Beyond portal website, DML-JP provides subject-specific metadata through OAI-ORE. By the schema it is enabled that digital repositories can load the rich metadata which were added by mathematicians.

1 Introduction and Backgrounds

In Japan about 70000 mathematical articles which had been reviewd in Math. Reviews were published in 400 journal titles [1]. Nowadays electronic edition of these journal titles are loaded on various digital repositories, which are partly supported by SPARC Japan [4] and CSI project [5]. Among such digital repositories one major repository is projecteuclid.org and the other is institutional repositories in Japan.

Contributions of these articles for DML for journal titles published in Japan are so important that we were planning to establish the potal website of the articles. Until Nov. 2008 about 20 small scale mathematical journals were loaded on institutional repositories [1, 2] and since 2005 projecteuclid.org have loaded 10 major mathematical journals published in Japan.

Considering these backgrounds, we constructed an experimental DML-JP as a portal website based on metadata harvesting. The titles joined with DML-JP are shown in the following.

```
Bull. Tokyo Gakugei University Sec. I
Bulletin of College of Science the University Ryukyu
Hiroshima Math. J.
Hokkaido Mathematical Journal
J. Math. Soc. Japan
Japan J. Indust. Appl. Math.
Journal of Mathematical Sciences, The University of Tokyo
Journal of the Faculty of Education, Kagoshima University
Journal of the Faculty of Science Shinshu University
Journal of the Faculty of Science, Kagoshima University
Journal of the Faculty of Science, the University of Tokyo
  Sect 1 A
Journal of the Faculty of Science, Yamagata University
```

```
Nagoya Math. J.
Kodai Math. J.
Nat. Sci. J. Fac. Educ. Hum. Sci. Yokohama National University
  Sec. I
Natur. Sci. Report. Ochanomizu. Univ.
Nihonkai Mathematical Journal
Osaka J. Math.
Proc. Japan Acad. Ser. A Math. Sci.
Publ. Res. Inst. Math. Sci.
Reports of the Faculty of Science and Engineering,
  Saga University. Mathematics
RIMS Kokyuroku
Ryukyu Mathematical Journal
Sci. Rep. Yokohama National University Sec. I
The science reports of the Kanazawa University
Tohoku Math. J.
Tokyo J. of Math.
Tsukuba Journal of Mathematics
```

2 Implementation

Platform of DML-JP is based on EPrints 3.1.1 software. We choosed the software because it was widely used and actively developed. As described above main contents of DML-JP are metadata harvested from digital repositories and the first work for DML-JP is to transform the harvested metadata into the format which is suitable for the platform. In this section we show the part.

2.1 Metadata harvesting

A standard metadata format for institutional repositories in Japan is junii2 format which is suitable to describe bibliographic information of journal articles. For projecteuclid.org and arxiv.org we choosed oai_dc format because these repository provides integrated bibliographic information in dc:identifier elements.

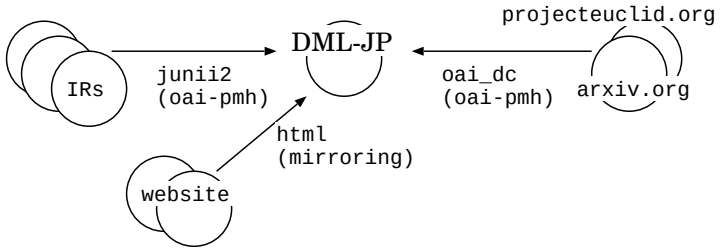

Fig. 1. Metadata harvesting

Because our target is mathematical journals published in Japan, as shown in [1], we are harvesting 16 institutional repositories and two subject repositories.

The number of articles is over 30000. This result means that about the half of all articles published in Japanese mathematical journals are grasped.

We should manage two metadata formats. The one is oai_dc which project euclid provides. The other is junii2 format which is standard format for institutional repositories for metadata exchange in Japan. The following is an example of oai_dc format metadata which is provided from Project Euclid.

```
<record>
<header>
<identifier>
  oai:CULeuclid:euclid.jmsj/1240435759
</identifier>
<datestamp>2009-04-23</datestamp>
<setSpec>jmsj</setSpec>
</header>
<metadata>
<oai_dc>
  <dc:title>
   Minimal 2-regular digraphs with given girth
  </dc:title>
  <dc:creator>BEHZAD, Mehdi</dc:creator>
  <dc:subject>05C20</dc:subject>
  <dc:publisher>Mathematical Society of Japan</dc:publisher>
  <dc:date>1973-01</dc:date>
  <dc:type>Text</dc:type>
  <dc:format>application/pdf</dc:format>
  <dc:identifier>
   http://projecteuclid.org/euclid.jmsj/1240435759
  </dc:identifier>
  <dc:identifier>
   J. Math. Soc. Japan 25, no. 1 (1973), 1-6
  </dc:identifier>
  <dc:identifier>doi:10.2969/jmsj/02510001</dc:identifier>
  <dc:language>en</dc:language>
  <dc:rights>
   Copyright 1973 Mathematical Society of Japan
  </dc:rights>
</oai_dc:dc>
</metadata>
</record>
```

One of the difficulty of the oai_dc format above is analysis of bibliographic information in `dc:identifier` element owing to there exist various journal name, series, volume and issue format, which limitations of oai_dc specification involve.

The following is an example of junii2 format metadata which is provided from an institutional repository in Japan.

```
<record>
<header>
<identifier>oai:teapot.lib.ocha.ac.jp:10083/843</identifier>
<datestamp>2007-07-02T06:30:00Z</datestamp>
<setSpec>hdl_10083_792</setSpec>
</header>
<metadata>
<meta xmlns="http://ju.nii.ac.jp/junii2"
```

```
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xsi:schemaLocation="http://ju.nii.ac.jp/junii2
  http://www.nii.ac.jp/irp/info/junii2.xsd">
<title>
 CONDITIONALLY TRIMMED SUMS FOR INDEPENDENT RANDOM VARIABLES
</title>
<creator>KASAHARA, Yuji</creator>
<NDC>400</NDC>
<publisher>Ochanomizu University</publisher>
<type>Article</type>
<NIItype>Departmental Bulletin Paper</NIItype>
<format>application/pdf</format>
<format>191755 bytes</format>
<URI>http://hdl.handle.net/10083/843</URI>
<fullTextURL>
http://teapot.lib.ocha.ac.jp/ocha/bitstream/10083/843/1/KJ00004470846.pdf
</fullTextURL>
<issn>00298190</issn>
<NCID>AN00033958</NCID>
<jtitle>Natur. Sci. Rep. Ochanomizu Univ.</jtitle>
<volume>46</volume>
<issue>2</issue>
<spage>9</spage>
<epage>12</epage>
<dateofissued>1995-12-30</dateofissued>
</meta>
</metadata></record>
```

An advantage of the junii2 format above is that each bibliographic element is defined as an entity, which makes it easy to retrieve bibliographic information, however, some institutional repository does not include journal title in English and even if included the expression does not coincide the expression of Math. Reviews. By that reason it is relatively hard to retrieve MR code and MSC from Math. Reviews database. Moreover, Japanese letters are included within several fields in original metadata.

The two metadata formats were transformed into EPrints XML format. Once bibliograhic information is retrieved, it is easy. The following is an example of EPrints XML format. For DML-JP field msc_p, msc and mr were added to default configuration.

```
<?xml version="1.0" encoding="utf-8" ?>
<eprints>
  <eprint xmlns="http://eprints.org/ep2/data/2.0">
  <rev_number>1</rev_number>
  <eprint_status>archive</eprint_status>
  <userid>1</userid>
  <metadata_visibility>show</metadata_visibility>
  <type>article</type>
  <ispublished>pub</ispublished>
  <subjects>
    <item>20-xx</item><item>QA</item>
  </subjects>
  <refereed>TRUE</refereed>
  <full_text_status>public</full_text_status>
```

```
  <date_type>published</date_type>
  <publication>Natur. Sci. Report. Ochanomizu. Univ.</publication>
  <datestamp>2007-08-01T01:50:05Z</datestamp>
  <title>
  Note on the Schur multiplier of a certain semidirect product
  </title>;
  <creators_name><item><family>Horie</family>
    <given>Mitsuko</given></item></creators_name>
  <official_url>http://hdl.handle.net/10083/839</official_url>
  <pagerange>85-88</pagerange>
  <volume>45</volume>
  <date>1994-12-15</date>
  <publisher>Ochanomizu Univeristy</publisher>
  <msc_p>20J06</msc_p>
  <msc><item>20C25</item></msc>
  <mr>1317509</mr>
  <related_url><item>
   <url>http://www.ams.org/mathscinet-getitem?mr=1317509</url>
   <type>MathSciNet</type></item></related_url>
  </eprint>
</eprints>
```

2.2 Metadata managements

From viewpoint of mathematical communication, there are several metadata entries for an article which describe mathematical classifications, reviews and locations of preprints. An identifier of an article is MR number which specify the review in Math. Reviews published by American Mathematical Society (AMS) in the form `http://www.ams.org/mathscinet-getitem?mr=`*id_number*. AMS also provides Mathematics Subject Classification which is a comprehensive classification for mathematical literatures. Authors of mathematical literatures are required to specify at least one classification. In mathematics and theoretical physics preprints play an important role for scholarly communication. It is necessary for researchers to know the locations of preprints for each article which have not been published in any journals.

Considering the resercher's needs, the set of harvested metadata is not necessarily enough to describe each article.

2.3 Examples

A typical example is an entry `dmljp.math.sci.hokudai.ac.jp/32786/`. From the url we can get the information in the following table. Prefix IR means that the entry was retrieved from IR and MR means Math. Reviews.

```
  IR Author: Maeda, Masao
  IR Title: The four-or-more Vertex Theorems in 2-dimensional
     Space Forms
  IR Citation: Nat. Sci. J. Fac. Educ. Hum. Sci. Yokohama National
               University Sec. I, 1 (1998) . pp. 43-46.
  IR Official URL: http://hdl.handle.net/10131/1069
```

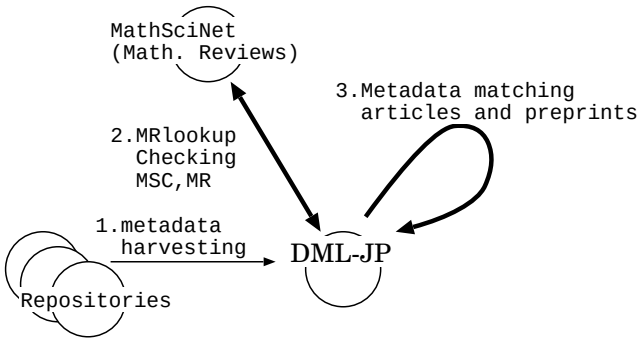

Fig. 2. Metadata processing

```
MR MSC Primary:   53A35, 53A, 53
MR MSC Secondary: 53A04, 53A, 53
MR Math. Reviews ID: 1710269
MR Review URL: http://www.ams.org/mathscinet-getitem?mr=1710269
```

Though this journal is so small and interdisciplinary that only this article is reviewed and indexed in Math. Reviews, you can find in the review URL that this article was cited from a review article in the field.

2.4 Preparation for OAI-ORE and SWORD

Owing to full text PDF files of DML-JP are stored in digital repositories and the quality of their mathematical metadata is not enough for institutional repositories, MR code and MSC should be reflected to add the value for the repository contents. For these type of collaboration, we would like to provide the metadata by OAI-ORE Atom Serialization format.

In the Resource Map of each article we aggregate official url and DML-JP url. In the entry of DML-JP we prepare an XML file in METS metadata format which could be imported to original repositories via SWORD protocol which many digital repository communities have already choosed as inter repository interfaces.

We intend to establish resource finding and exchange schema between digital repositories by the implementation, which is merely experimental phase.

Though only OAI-ORE Atom serialization for official url was implemented at this time, METS format metadata is easily generated by a function of EPrints. So the implementation of the picture above will be realized within a year. The following is a part of an example of ORE Atom serialization.

```
<!-- Aggregated Resources -->
<atom:link href='http://projecteuclid.org/euclid.kmj/1138846413'
  title='A remark on derived spaces'
  rel='http://www.openarchives.org/ore/terms/aggregates' />
```

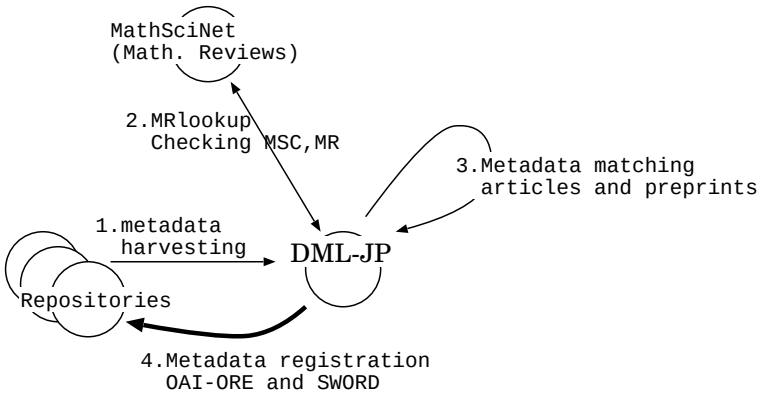

Fig. 3. Metadata registration

```
<atom:link href='http://projecteuclid.org/euclid.tmj/1192117987'
  title='Spectral synthesis in the Fourier algebra and the
     Varopoulos algebra'
  rel='http://www.openarchives.org/ore/terms/aggregates' />
```

3 Statistics in DML-JP

In this section we show statistics of the journals which are the targets of DML-JP. The first result is performance of the journals published in Japan.

3.1 The number of articles for each research fields

The first result is the percentage in the journal articles and whole articles within each MSC shown in Table 1, which is retrieved from Math. Reviews. There are 12 research fields in which the table shows the article share from 5 percent to 10 percent. These research fields also are active in Japan from mathematician's intuition. DML-JP covers about 50 % of the articles and moreover there are several mathematical papers which are not indexed by Math. Reviews.

3.2 Application of HITS algorithm

The second result is based on HITS [9, 10] algorithm which is widely applied in ranking of webpages. Because HITS itself is for weighted directed graph we can apply it for relation of research fields if we make such a graph for them. For structure matrix M of a weighted directed graph hub score (H-score) of a node is defined as the value of the correspondent element of maximal eigenfunction for M^tM and authority score (A-score) as the value of MM^t.

Let the node set be the first two digits of MSC. If an article specify MSC Primary A and MSC Secondary B, we set an edge from A to B and add weight

%	Articles/Total	MSC Primary
10.62	(1923/18103)	57 Manifolds and cell complexes
10.00	(1852/18506)	32 Several complex variables and analytic spaces
9.48	(545/5748)	31 Potential theory
9.46	(1048/11077)	55 Algebraic topology
9.20	(1902/20655)	14 Algebraic geometry
8.15	(3307/40538)	53 Differential geometry
7.68	(875/11392)	13 Commutative rings and algebras
7.45	(525/7041)	12 Field theory and polynomials
6.58	(2301/34968)	11 Number theory
6.25	(734/11742)	22 Topological groups, Lie groups
5.84	(1922/32891)	30 Functions of a complex variable
5.44	(1305/23970)	16 Associative rings and algebras

Table 1. Performance of the journal

1 to the edge, which is a fragment of the graph constructed from an article. We have whole graph for all of target articles as a result. Figure 4 shows the process and the directed graph for each year is shown in URL `oaia.math.sci.hokudai.ac.jp/navi/jp-a/`.

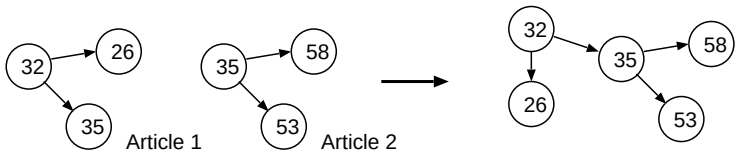

Fig. 4. Fragment of directed graph generated by two article.

Figures 5 shows time series of ranking by H-score and A-score and the scores themselves for the first six research fields in Table 1. The value for each year of the time series is calculated by the articles published in the following ten years. For example the value of 1990 is from the graph generated by articles published from 1990 to 1999.

We can see that the ranking from these scores does not coincide the ranking of Table 1 and moreover is not in proportion to the number of articles. On one hand, in the six research fields shown in Figure 4, tendency of the scores and ranks of Potential theory (MSC 31) and Algebraic topology (MSC 55) is not so high as shown in Table 1. On the other hand, Figure 6 shows the typical difference. In Partial differential equation (MSC 35), there are huge number of articles are published in the world. So the performance is estimated relatively low in Table 1. Despite that, the scores and ranks shown in Figure 6 are high. In Number theory, it means that the influence is strong more than the ranking of the number of published articles.

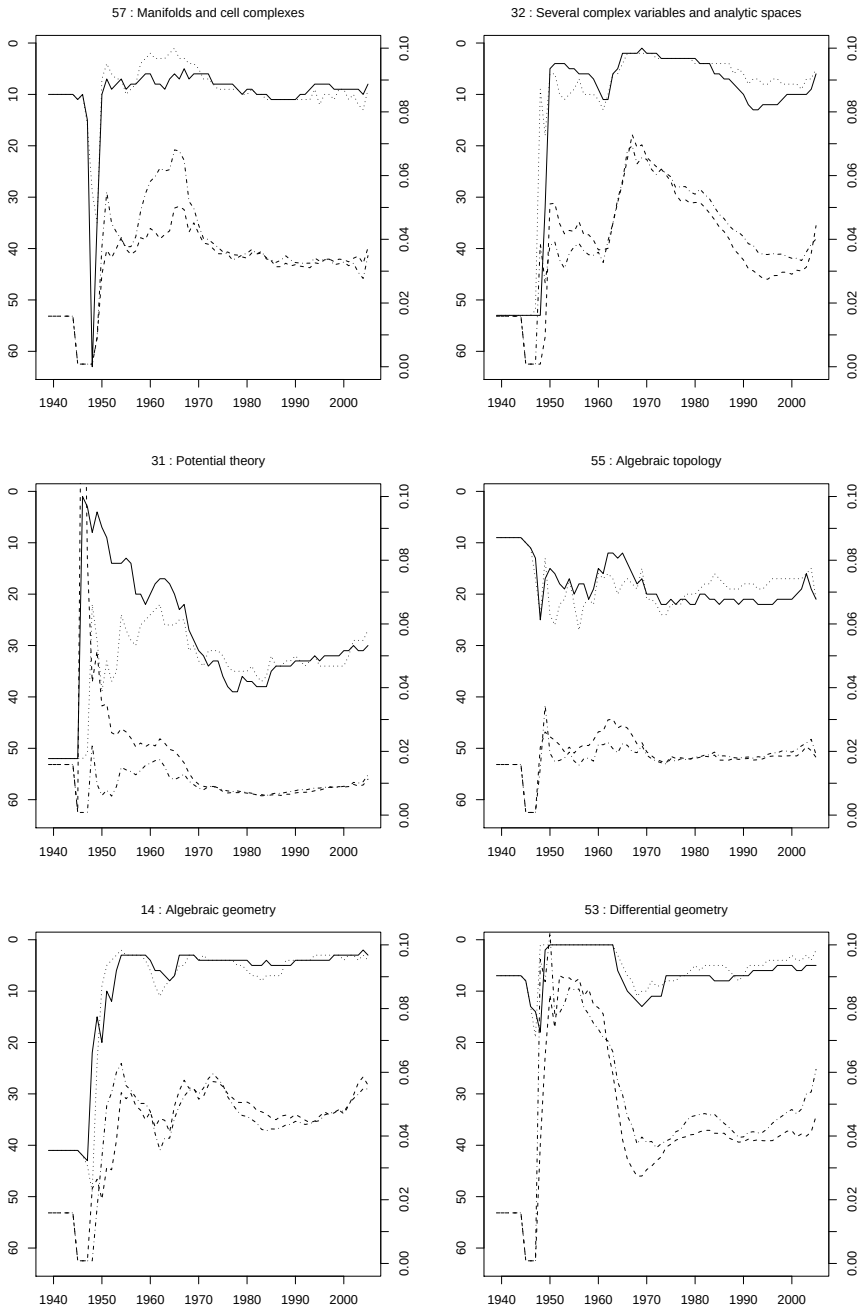

Fig. 5. Time series of H-score, A-score and ranking by the scores. Solid line: H-score, Dotted line: A-score, Broken line: value of H-score, Dotted broken line: value of H-score.

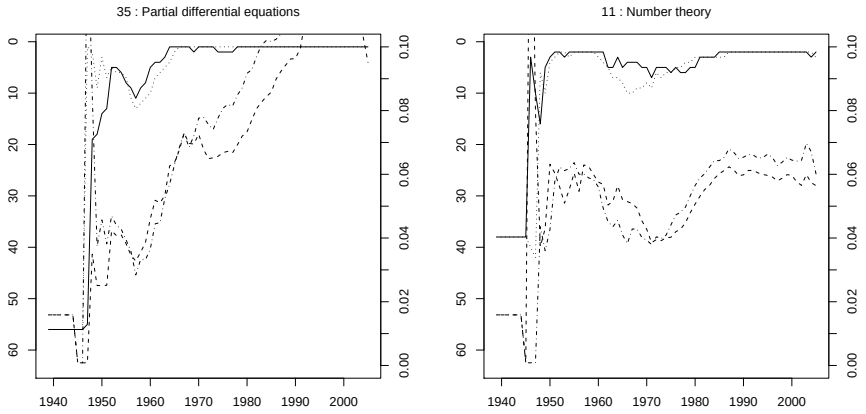

Fig. 6. HITS results for MSC 35 and 11

4 Discussions and Future work

DML-JP is a collaborating work with librarians and mathematical community. From a view of applied mathematics, it is essentially important to disseminate these articles on subject portal website for widely usable objectives. In Section 3 we show several viewpoint to represent activities on mathematics in Japan. It is important to have various methods to estimate the activities.

Unfortunately OCR technology for mathematical expression is not familliar with community outside mathematical publishing. We are planning to mirroring OA articles of these journals and providing full-text by xml+mathml format with certain presision as far as possible.

Though DML-JP introduced in the article is experimental DML, we consider that we can develope it by the advantage of metadata based repository.

5 Acknowledgement

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6. ORE Specification http://www.openarchives.org/ore/
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8. InftyReader http://www.sciaccessnet.org/
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