A Step Forward: Adding Linked Data Vocabularies to Digital Repositories

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A Step Forward: Adding Linked Data Vocabularies to Digital Repositories

Sai Deng, University of Central Florida Libraries
Linked Data Basics

• Linked data:
  • “A term used to describe a recommended best practice for exposing, sharing, and connecting pieces of data, information, and knowledge on the Semantic Web using URIs and RDF.”
    -Wikipedia

• Resource Description Framework (RDF): Represent information in triples
  • **Subject**: a resource, identified with a URI
  • **Predicate**: specification of the relationship
  • **Object**: a resource the subject is related to
Linked Data Basics

• The Four Design Principles of Linked Data
  • Use Uniform Resource Identifiers (URIs) as names for things.
  • Use HTTP URIs so that people can look up those names.
  • When someone looks up a URI, provide useful information, using the standards (RDF, SPARQL).
  • Include links to other URIs so that they can discover more things.

• URIs for naming things, RDF for describing things, SPARQL for querying data; link to other URIs to find more things.
Linked Data: An Example

- Comedy of The tempest
- Plays
- Spirits
- Fathers and daughters
- Shipwreck victims
- The tempest
- Is an example of schema:exampleOfWork
- Is about schema:about
- Is contributed by schema:contributor
- A midsummer night's dream
- Is written by schema:creator
- The Norton Shakespeare
- Has format schema:bookFormat
- John C. Crowther
- PrintBook
- Henry V
- Is written by schema:creator
- William Shakespeare

*Based on information from worldcat.org*
Linked Open Data Building Blocks

- **The LOD Data Model**: RDF triples
- **Content Rules**: relies on external vocabularies and ontologies
- **Metadata schema**
  - RDF Schema
  - Vocabulary Building Blocks: SKOS, OWL
  - Open Archives Initiative Object Reuse and Exchange (OAI-ORE)
- **Serializations of LOD**
  - RDF Notation-3/Ns, Turtle, N-Triples; RDFa; JSON-LD
- **Exchanging LOD**
  - SPARQL
- **Mitchell, Erik T.** Building Blocks of Linked Open Data in Libraries. *Library Technology Reports* (vol. 49, no. 5)
Five Star-schema of Linked Open Data (LOD)

- Five star-schema of Linked Open Data (Tim Berners-Lee)

  ★ Available on the web (whatever format) but with an open licence, to be Open Data

  ★★ Available as machine-readable structured data (e.g. excel instead of image scan of a table)

  ★★★ as (2) plus non-proprietary format (e.g. CSV instead of excel)

  ★★★★ All the above plus, Use open standards from W3C (RDF and SPARQL) to identify things, so that people can point at your stuff

  ★★★★★ All the above, plus: Link your data to other people’s data to provide context


Source: [https://www.w3.org/DesignIssues/LinkedData.html](https://www.w3.org/DesignIssues/LinkedData.html)
Linked Data Examples and Datasets

- LC Linked Data Service: Authorities and Vocabularies [https://id.loc.gov/](https://id.loc.gov/)
- FAST: Faceted Application of Subject Terminology [http://id.worldcat.org/fast](http://id.worldcat.org/fast)
- Virtual International Authority File (VIAF) [https://viaf.org/](https://viaf.org/)
- Worldcat Identities [www.worldcat.org/identities](http://www.worldcat.org/identities)
- Open Researcher and Contributor ID (ORCID) [https://orcid.org/](https://orcid.org/)
- International Standard Name Identifier (ISNI) [http://www.isni.org/](http://www.isni.org/)
- Schema.org Vocabulary [http://schema.org/docs/gs.html#schemaorg](http://schema.org/docs/gs.html#schemaorg)
- The Linked Open Data Cloud [https://lod-cloud.net/](https://lod-cloud.net/)
Linked Data Implementations

- Google Knowledge Graph
Linked Data Implementations

- Libraries, Archives and Museums Community
  - Europeana [http://europeana.eu](http://europeana.eu)
  - DPLA [http://dp.la](http://dp.la)
  - LIBRIS [https://libris.kb.se/](https://libris.kb.se/)
  - British National Bibliography [http://bnb.bl.uk/](http://bnb.bl.uk/)
  - BIBFRAME [http://BIBFRAME.org/](http://BIBFRAME.org/)

- The Web and the Library Community
  - Schema.org
    - Bibliographic Extension
    - Extend Schema.org to represent archives
      [https://archival.github.io/schema-org/](https://archival.github.io/schema-org/)

- More Library Experiments/Cases
  - WorldCat Works (schema:exampleOfWork) [http://experiment.worldcat.org/entity/work/data/1080130963](http://experiment.worldcat.org/entity/work/data/1080130963)
  - Check out ALA conference programs on LOD in the past few years, e.g., Linked Library Data IG
Current Digital Repositories and Linked Data

- **Islandora**
  - Effort in mapping MODS to RDF;
  - Fedora 4, LDP implementation; Islandora CLAW

- **Experiments and Cases:**
  - [Islandora CLAW](#)
  - [TU Delft repository example: Colonial Architecture](#) (Delftdora module, Fedora 3)
  - [A Lightweight Structured Data Implementation Using JSON-LD and Schema.org for Digital Repository](#) (Mak et al.)
Current Digital Repositories and Linked Data

- CONTENTdm
- Not inside the system, but work on exported data;

- UIUC. Challenges of Mapping Digital Collections Metadata to Schema.org (Lampron et. al. 2016)


A UIUC Experiment: http://imagesearch-test1.library.illinois.edu/cdm/ref/collection/motley-new/id/599
Project Site: http://publish.illinois.edu/linkedspcollections/
Current Digital Repositories and Linked Data

• Omeka
  • Open source web publishing platform. Supports Dublin Core. Can export METS, dc-rdf, JSON etc.
  • Ozmeka (plug-ins)/ Omeka linked data

• DSpace
  • DSpace Linked Data support spans all three Layers: “the storage layer with a triple store, the business logic with classes to convert stored contents into RDF, and the application layer with a module to publish RDF serializations.”
  - Donohue. Linked (Open) Data.
    (https://wiki.duraspace.org/display/DSDOC6x/Linked+%28Open%29+Data)
Current Digital Repositories and Linked Data

• Digital Commons
  • Allow to add extra fields for links (not RDF)

• Preparing for Linked Data
  • Include links (e.g., id.loc.gov, viaf.org) in added additional fields for author, advisor, department names etc.;

• Data (in spreadsheet) cleanup and reconciliation using OpenRefine
  • Name review can be tricky and time-consuming: Google, Wikipedia, obituary, university and departmental websites, publications, CVs...
Adding Linked Data Vocabularies to UCF Digital Repositories

• Adding LOD Links to Fields in Digital Repositories
  • Authors/Creators
  • Contributors, e.g., thesis advisors
  • Corporate names, e.g., university, college and departmental names
  • Subjects
  • Person identifiers

• OpenRefine
  • Download and installation
    http://openrefine.org/download.html
  • Documentation
    https://github.com/OpenRefine/OpenRefine/wiki/Documentation-For-Users
  • Features
    • Import
    • Facet
    • Edit cells: Clustering...
    • Edit columns: Add Column based on this column; Fetching URLs from Web Services (*Enrich existing data columns)...
    • Expressions
    • Export
    • History...
Adding LC and VIAF Links to Advisor Names

Open OpenRefine — Choose Files — Select advisors-RTDs.xlsx — Click “Next”
Adding LC and VIAF Links to Advisor Names

Click "Create Project"
Adding LC and VIAF Links to Advisor Names

Faceting

After clicking “Facet – Text facet”
Adding LC and VIAF Links to Advisor Names

Click “Cluster” on the left, or click “Edit Cells – Cluster and edit” under “advisor” column.
Adding LC and VIAF Links to Advisor Names

Cluster & Edit column "advisor"

Adding LC and VIAF Links to Advisor Names

Cluster & Edit column “advisor”: Try other algorithms

<table>
<thead>
<tr>
<th>Cluster Size</th>
<th>Row Count</th>
<th>Values in Cluster</th>
<th>Merge?</th>
<th>New Cell Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>8</td>
<td>• Frank, Fredric D. (7 rows)</td>
<td>☑</td>
<td>Frank, Frederic D.</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>• Schrader, George F. (5 rows)</td>
<td>☑</td>
<td>Schrader, George F.</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>• Snelson, Franklin F. (4 rows)</td>
<td>☑</td>
<td>Snelson, Franklin F.</td>
</tr>
</tbody>
</table>

Cluster & Editing: Method nearest neighbor, Distance Function levenshtein, Radius 1.0, Block Chars 6
Adding LC and VIAF Links to Advisor Names

Reconciliation

Sort by advisor;

Click “Reconcile—Start reconciliation”
Adding LC and VIAF Links to Advisor Names

How to set up LoC Reconciliation Service

Click “Add Standard Service”;

Enter the service's URL:

https://lc-reconcile.herokuapp.com/

Add Service
Adding LC and VIAF Links to Advisor Names

Reconciliation

Leave “Names” as default;
Click “Start Reconciling”

Matched 313 (about 32.33%).
Adding LC and VIAF Links to Advisor Names

Review

• For names linked, click the name to check;

• If it’s not the right person, click “Choose new match”;

• It opens several options, re-check and apply.
Click the link under “Acierno, Louis J.”, it opens: http://id.loc.gov/authorities/names/n85099714.html

Acierno, Louis J., 1920-

Sources
found: His Comprehensive cardiac rehabilitation and prevention, c1985: CIP t.p. (Louis J. Acierno, M.D., F.A.C.C., F.A.C.P.; associate prof. of pub. health, Univ. of Central Fla.) data sheet (b. 1920)
found: His A history of cardiology, 1993: CIP t.p. (L.J. Acierno; Univ. of Florida, USA)
Adding LC and VIAF Links to Advisor Names

Review

- For names unlinked, click the other options to check (e.g., the LC links below);
- If it’s the right person, click ✓ or ✓✓ to apply;
- If no right name found, click “Create new topic”;
- Input the right name and apply.

Clausen, Chris A., 1940-  http://id.loc.gov/authorities/names/n78032138.html
Sources
found: His Principles of industrial ... 1978: t.p. (Chris A. Clausen, Dept. of Chem., Fla. Tech. U., Orlando) pub. info. (b. 12/7/40)

Doering, Robert D., 1925-  http://id.loc.gov/authorities/names/no2018055990.html
Has Affiliation
  Organization: Florida Technological University
  Organization: University of Central Florida. Department of Industrial Engineering and Management Systems
  Associated Locale  Orlando (Fla.)
Adding LC and VIAF Links to Advisor Names

Narsingh Deo, 1936-  
[http://id.loc.gov/authorities/names/n2006056273.html](http://id.loc.gov/authorities/names/n2006056273.html)

Sources
found: Sysło, Maciej M. *Discrete optimization algorithms*, 2007: CIP t.p. (Narsingh Deo)
found: LC database, July 20, 2006: (Deo, Narsingh, 1936-)

...Narsingh Deo is a professor and Charles N. Millican Endowed Chair of the Department of Computer Science, University of Central Florida...

Books  

Review

- If LCNAF doesn’t provide enough information, further check the web (e.g., Wikipedia, Amazon books, obituaries, university website, newsletter...)

- When confirmed that it’s the right person, click ✓ or ✓✓ to apply.
## Adding LC and VIAF Links to Advisor Names

### Add Column for URLs

- **Edit column**—Add column based on this column
- In the opened new window, fill in:
  - **New column name:** advisor_lc
  - **Expression:** cell.recon.match.id
Adding LC and VIAF Links to Advisor Names

<table>
<thead>
<tr>
<th>#</th>
<th>Identifier</th>
<th>Advisor</th>
<th>Advisor LC</th>
</tr>
</thead>
<tbody>
<tr>
<td>146</td>
<td>DP0011933</td>
<td>Adicks, Richard R.</td>
<td></td>
</tr>
<tr>
<td>711</td>
<td>DP0013883</td>
<td>Alsaka, Yacoub A.</td>
<td></td>
</tr>
<tr>
<td>712</td>
<td>DP0013884</td>
<td>Anderson, Loren A.</td>
<td><a href="http://id.loc.gov/authorities/n80002784">http://id.loc.gov/authorities/n80002784</a></td>
</tr>
<tr>
<td>881</td>
<td>DP0017018</td>
<td>Anderson, Loren A.</td>
<td><a href="http://id.loc.gov/authorities/n80002784">http://id.loc.gov/authorities/n80002784</a></td>
</tr>
<tr>
<td>949</td>
<td>DP0019440</td>
<td>Anderson, Loren A.</td>
<td><a href="http://id.loc.gov/authorities/n80002784">http://id.loc.gov/authorities/n80002784</a></td>
</tr>
<tr>
<td>3</td>
<td>DP0000186</td>
<td>Armstrong, Jack</td>
<td></td>
</tr>
<tr>
<td>664</td>
<td>DP0013700</td>
<td>Armstrong, Lee H., 1941-</td>
<td><a href="http://id.loc.gov/authorities/n79131864">http://id.loc.gov/authorities/n79131864</a></td>
</tr>
</tbody>
</table>

Add Column for URLs: LC Links added
Adding LC and VIAF Links to Advisor Names

Add a duplicate column for advisor

New column name: advisor_c
Expression value: [advisor_c] Reconciliation

Select Virtual International Authority File service
(*Give more options to choose from if not matched directly)

Or, select VIAF-LC service

---

<table>
<thead>
<tr>
<th>advisor_c</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yousef, Yousef A.</td>
<td>Choose new match</td>
</tr>
<tr>
<td>Aqoudah, Mohammad Ali Yousef</td>
<td>(1)</td>
</tr>
<tr>
<td>Yousef, Hassan A.</td>
<td>(1)</td>
</tr>
<tr>
<td>Yousef, Ahmad Mohamed Fahmy</td>
<td>(1)</td>
</tr>
<tr>
<td>Mousa, Wael A. Yousef</td>
<td>(1)</td>
</tr>
<tr>
<td>Yousef, Ellohim A. A.</td>
<td>1962- Yousef, Mahmod A. M. (1)</td>
</tr>
</tbody>
</table>

---

How to set up VIAF-LC Reconciliation Service
Click “Add Standard Service”;
Enter the service’s URL:
http://refine.codefork.com/reconcile/viaf/LC

How to set up Virtual International Authority File service
Enter the service’s URL:
http://iphylo.org/~rpage/phyloinformatics/services/reconciliation_viaf.php
Adding LC and VIAF Links to Advisor Names

Add VIAF Links

New column name: advisor_viaf
Expression: "https://viaf.org/viaf/" + cell.recon.match.id

VIAF links added
Adding LC and VIAF Links to Advisor Names

• Display in the IR

*Add both links or only one type of link for advisors (e.g., VIAF, or LC)

http://stars.library.ucf.edu/rtd/80/

http://stars.library.ucf.edu/rtd/211/
Adding LC and VIAF Links to Author Names

• Using Expression to Format Multiple Links
  • Expression Language: General Refine Expression Language (GREL)
  • First, run reconciliations and get VIAF and LC links;
  • Then add columns, e.g.,
    • Edit column – Add column based on this column
    • New Column name: author1_viafurl
      • Expression: "http://viaf.org/viaf/" + cell.recon.match.id
    • Edit column – Add column based on this column
    • New column name: author1_lcurl
      • Expression: cell.recon.match.id
Adding LC and VIAF Links to Author Names

• Using Expression to Format Multiple Links
  • Add column based on this column
    • New column name: author1_viafurl_lcurl
    • Expression:
      cells["author1_viafurl"].value + " " + cells["author1"].value + "[VIAF] " + cells["author1_lcurl"].value + " " + cells["author1_copy"].value + "[LC]"

<table>
<thead>
<tr>
<th>author1_lcurl</th>
<th>author1_viafurl</th>
<th>author1_viafurl_lcurl</th>
</tr>
</thead>
</table>
Adding LC Subject Links to IR Records

• Create a project for one “UCF Forum” dataset in OpenRefine;
  • Its keywords field has a mixture of controlled and uncontrolled terms taken from the articles and supplied by the Metadata Librarian;
  • The goal is to add LOD links for the controlled terms.

• Splitting Keywords into Several Columns

Under “Keywords”, click “Edit column – Split into several columns”; “by separator “;”
Adding LC Subject Links to IR Records

- Create a project for one “UCF Forum” dataset in OpenRefine;
- Keywords splitted into Several Columns

Top graph:
Keywords splitted (by default, e.g., keywords 1, 2, 3...)

Rename the fields, delete the space in field names
keywords 1, 2, 3... → keyword1, 2, 3...

Left graph:
Reconcile column “keyword1”
Reconcile each cell against LoC Reconciliation Service
Adding LC Subject Links to IR Records

- Review, select and confirm matched values (when needed)

<table>
<thead>
<tr>
<th>keyword1</th>
<th>keyword2</th>
<th>keyword3</th>
<th>keyword4</th>
<th>keyword5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hispanics</td>
<td>Hispanic community</td>
<td>Hispanic culture</td>
<td>Immigrants</td>
<td>Diversity</td>
</tr>
<tr>
<td>Hispanics of achievement (55)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanics in Philanthropy (53)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanics in the United States (46)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Match this topic to this cell

Show: 5 10 25 50 rows

Edit column – Add column based on this column
Adding LC Subject Links to IR Records

- Adding column for links

<table>
<thead>
<tr>
<th>102 rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-11-02T09:03:00Z</td>
</tr>
<tr>
<td>2016-11-02T09:03:00Z</td>
</tr>
</tbody>
</table>

New column name

**keyword1_url**

**Expression**

```
cell.recon.match.id + " | " + cell.recon.match.name
```

Links added for **keyword1**;
Repeating the same process for **keyword2**, 3, 4, ...

<table>
<thead>
<tr>
<th>102 rows</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017-03-01T00:00:00Z</td>
</tr>
<tr>
<td>2017-03-01T00:00:00Z</td>
</tr>
</tbody>
</table>
Adding LC Subject Links to IR Records

• Putting Links together

Putting all subjects and their links together in a column

New column name  subjects_linked

Expression  subjects_linked

<table>
<thead>
<tr>
<th>Expression</th>
<th>Subjects Linked</th>
</tr>
</thead>
<tbody>
<tr>
<td>if(isBlank(cells[&quot;keyword1_url&quot;].value), &quot; &quot;, cells[&quot;keyword1_url&quot;].value) + &quot; &quot; + if(isBlank(cells[&quot;keyword2_url&quot;].value), &quot; &quot;, cells[&quot;keyword2_url&quot;].value) + &quot; &quot; + if(isBlank(cells[&quot;keyword3_url&quot;].value), &quot; &quot;, cells[&quot;keyword3_url&quot;].value) + &quot; &quot; + if(isBlank(cells[&quot;keyword4_url&quot;].value), &quot; &quot;, cells[&quot;keyword4_url&quot;].value) + &quot; &quot; + if(isBlank(cells[&quot;keyword5_url&quot;].value), &quot; &quot;, cells[&quot;keyword5_url&quot;].value) + &quot; &quot; + if(isBlank(cells[&quot;keyword6_url&quot;].value), &quot; &quot;, cells[&quot;keyword6_url&quot;].value) + &quot; &quot;</td>
<td></td>
</tr>
</tbody>
</table>

Subject links display together

* Use “|” or other dividers to separate subjects
Adding LOD Links to IR Records

An Example in the IR
http://stars.library.ucf.edu/ucf-forum/186/
# Adding FAST by Fetching URLs

Add column by fetching URLs based on Topical Subject column
(Click “Edit column—add column by fetching URLs” under “Topical_Subject”)  

**New column name**

fast_url  

**Expression**

```
"http://experimental.worldcat.org/fast/search?query=oclc.heading+exact+%22"+value.replace(/(\s)/,'%20')+%22&httpAccept=application/rdf%2bxml"
```

*Query FAST for RDFXML*
Adding FAST by Fetching URLs

Need to extract FAST ID from the returned content:

```xml
<dct:identifier>799558</dct:identifier>
...
<dc:format>application/rdf+xml</dc:format>
```
Adding FAST by Fetching URLs

Edit cells – Transform...
Adding FAST by Fetching URLs

Text Transformation
(Extract FAST identifier from the returned content)

Expression
"http://experimental.worldcat.org/fast/"+value.parseHtml().select('dct.identifier')[0].htmlText()
Adding FAST by Fetching URLs

FAST links added

*If returned text doesn’t include a FAST identifier, it’ll display the original text; If more than one match, will pick up the first one (index[0])
Other Possibilities

- **Augment Data with Reconciliation Services**
  - Reconcile genre values to AAT terms
  - Reconcile places to GeoNames
  - Reconcile ORCID...

- **Reconcile Against Local Vocabularies**
  - reconciliation-csv
    - Possibilities: Reconcile various fields in OpenRefine against local controlled term lists, e.g., medals, ranks for Veterans Oral History

- **Next Steps**
  - Keep adding more LOD links to personal names, subjects and college/department names to digital collections;
  - Continue to explore OpenRefine and related services to enrich metadata and improve workflow;
  - Promote, explore and link authors/researchers to personal identifiers.
Resources

- Berners-Lee, Tim. Linked Data [https://www.w3.org/DesignIssues/LinkedData.html](https://www.w3.org/DesignIssues/LinkedData.html)
- BIBFRAME [http://BIBFRAME.org/](http://BIBFRAME.org/)
- DPLA [http://dp.la](http://dp.la)
- Europeana [http://europeana.eu](http://europeana.eu)
- FAST: Faceted Application of Subject Terminology [http://id.worldcat.org/fast](http://id.worldcat.org/fast)
- International Standard Name Identifier (ISNI) [http://www.isni.org/](http://www.isni.org/)
- LC Linked Data Service: Authorities and Vocabularies [https://id.loc.gov/](https://id.loc.gov/)
- Mitchell, Erik T. Building Blocks of Linked Open Data in Libraries. Library Technology Reports (vol. 49, no. 5)
- Mitchell, Erik T. Three Case Studies in Linked Open Data. Library Technology Reports (vol. 49, no. 5)
- Open Researcher and Contributor ID (ORCID) [https://orcid.org/](https://orcid.org/)
Resources

- OpenRefine. Reconcilable data sources. [https://github.com/OpenRefine/OpenRefine/wiki/Reconcilable-Data-Sources](https://github.com/OpenRefine/OpenRefine/wiki/Reconcilable-Data-Sources)
- Orbis Cascade Alliance. OpenRefine for Metadata Cleanup. [https://www.orbiscascade.org/openrefine-for-metadata-cleanup/](https://www.orbiscascade.org/openrefine-for-metadata-cleanup/)
- Ozmeka. [https://github.com/ozmeka/ozmeka](https://github.com/ozmeka/ozmeka)
  Reconcile-csv in GitHub: [https://github.com/okfn/reconcile-csv](https://github.com/okfn/reconcile-csv)
- Schema.org Vocabulary [http://schema.org/docs/gs.html#schemao](http://schema.org/docs/gs.html#schemao)
- Tay, Aaron. OpenRefine, & reconciliation services - learning the ropes. [http://musingsaboutlibrarianship.blogspot.com/2017/03/openrefine-reconciliation-services.html](http://musingsaboutlibrarianship.blogspot.com/2017/03/openrefine-reconciliation-services.html)
- The Linked Open Data Cloud [https://lod-cloud.net/](https://lod-cloud.net/)
- Virtual International Authority File (VIAF) [https://viaf.org/](https://viaf.org/)
- Worldcat Identities [www.worldcat.org/identities](www.worldcat.org/identities)
Acknowledgements

• Lucas Mak, Metadata and Catalog Librarian, Michigan State University Libraries

• Systems, University of Central Florida Libraries

• Image credits
  • 5 Star Open data (http://5stardata.info/en/)
  • Linked Data (https://www.w3.org/DesignIssues/LinkedData.html)
  • Linked Open Data Cloud (https://lod-cloud.net/)
Thank you!

Contact
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Metadata Librarian & Associate Librarian
University of Central Florida Libraries
sai.deng@ucf.edu