Extracting Logical Hierarchical Structure of HTML Documents Based on Headings

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Background

• **Understanding of structure in web pages is important** for many applications
  • Web search
  • Automatic summarization of web pages
  • Web information extraction
Structure in web pages

• Web pages contain various types of structures
Structure in web pages

• Web pages contain various types of structures
  • Layout structure,
Structure in web pages

- Web pages contain various types of structures
  - Layout structure, list or table structure, ...
Structure in web pages

- Web pages contain various types of structures
  - Layout structure, list or table structure, ...
- We focus on **hierarchical heading structure**
  - 78% of pages contain it
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Hierarchical heading structure

• **Heading**
  • Topic description of a segment

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• **Block**
  • A segment with its heading
  • may contain each other

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<th>Open throughout the year.</th>
</tr>
</thead>
<tbody>
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</table>

#### History

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<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
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- **Block**
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  - may contain each other

- **Hierarchical heading structure**
  - composed of these headings and blocks

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• Traditional search engines:
  • This page contains both words
  • return this page incorrectly

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Importance of heading structure

2010 Mar

• Traditional search engines:
  • This page contains both words
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• Heading-aware engines:
  • “Mar.” occurs under “2012”, not “2010”
  • Will not return this page

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Problem to be solved

• Hierarchical heading structure is useful
• It seems easy to extract the structure
Problem to be solved

• Hierarchical heading structure is useful
• It seems easy to extract the structure
• In fact, it’s NOT easy

Our research problem: 
Extraction of hierarchical heading structure
Hierarchical heading structure extraction is NOT easy

• HTML has tags for describing headings
  • H1 to H6 and DT tags
Hierarchical heading structure extraction is NOT easy

• HTML has tags for describing headings
  • H1 to H6 and DT tags
• These tags are not always used or used incorrectly

In our data set:
• Only 32% of headings were tagged by these tags
• Only 67% of components tagged by these tags were headings
Hierarchical heading structure extraction is NOT easy

- HTML has tags for describing headings
  - H1 to H6 and DT tags
- These tags are not always used or used incorrectly
  - In our data set:
    - Only 32% of headings were tagged by these tags
    - Only 67% of components tagged by these tags were headings
- **More sophisticated extraction method is necessary**
Humans use visual style

• How do humans extract hierarchical heading structure?
Humans use visual style

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• They use **visual style**
  • consists of various visual attributes of components
  • e.g. font-size, color
Humans use visual style

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  • e.g. font-size, color
Visual style can be easily detected

- Visual style is assigned to each DOM node
  - DOM node is a pair of tags or a text fragment split by tags

```<LI>
  <B>
    Jul.
  </B>
  Construction started.
</LI>```
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Visual style can be easily detected

• Visual style is assigned to each DOM node
  • DOM node is a pair of tags or a text fragment split by tags
• Visual style can be easily detected by computers
• We use it to extract hierarchical heading structure
Disadvantages of existing methods

• There exists some methods that use visual style of nodes

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- Existing methods
  - check nodes one-by-one
  - [Okada, Arakawa]

Disadvantages of existing methods

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• Existing methods
  • check nodes one-by-one
  • compare two nodes and judge which one is more likely to be a heading

[Pembe, Güngör]

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Disadvantages of existing methods

- There exists some methods that use visual style of nodes
- Existing methods
  - check nodes one-by-one
  - compare two nodes and judge which one is more likely to be a heading
- They do not use global information within given page

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Our idea

• To use more information, our method
  • groups nodes by visual style into node sets
  • judges if each node set is a set of actual headings
• Each node set is
  • a set of headings of same level
  • or a set of non-headings
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Example node sets

- Node sets indicated by color

An example set of actual headings
Example node sets

• Node sets indicated by color

An example set of non-heading components.

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Outline of our method

1. Group candidate headings
2. Sort node sets by significance of their style
3. For each node set in desc. order of significance
   3.1 Judge if the node set is a set of actual headings
   3.2 For actual headings, also extract corresponding blocks

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Step 1. Group candidate headings

- Candidate heading nodes: a single text or image node
- Group candidates with exactly the same attribute values

Three types of attributes for grouping

1. Visual attribute values computed by web browsers
   - Font-size, font-style, font-weight, text-decoration, and color

2. Tag path
   - Sequence of node names between a node and the root
   - e.g. /HTML/BODY/TABLE/TR/TD/UL/LI/text()

3. Height of images
Step 2.
Sort node sets by significance of their style

Four sort keys in this priority order
1. Depth of corresponding *blocks* in hierarchy
   • because blocks never include blocks at upper levels
2. Font-size
3. Font-weight
4. Document order
   • because a heading of a parent block usually appear earlier than that of a child block
Step 3.
Scan node sets in order of significance

• Our method
  • recursively scans node sets in the descending order of their significance
  • When an actual heading set is found, extracts the blocks corresponding to the headings

• Two sub-steps
  3.1 Judge if a node set is an actual heading set
  3.2 Detect the corresponding blocks from headings
Step 3.1 Judging if a node set is actual heading set

5 heuristic rules

• e.g. all headings in one parent block are unique

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Step 3.2
Detecting corresponding blocks from headings

• When a node set passed all the rules, our method
  • regards it is an actual heading set
  • detects blocks corresponding to the headings

• To determine blocks from headings, our method use correspondence between them and DOM sub-tree
  • A heading corresponds to a single text or image node
  • A block corresponds to a *node array*, a set of adjoining sibling nodes and their descendants
The lowest common ancestor of the headings, “2010” and “2012”
The first node of "2010" node array

The first node of "2012" node array

LI

B text

Jul.

B

LI
text

Feb.

B

LI
text

Mar.

B

LI
text

Jul.
The last node of “2010” node array

The last node of “2012” node array

May.

UL

B

LI

2010

LI

LI

UL

UL

UL

LI

B

B

B

B

text

text

text

text

Jul.

Feb.

Mar.

Jul.
Experimental setting

To evaluate our method

• Random 803 pages from ClueWeb09
  • For excluding spam pages, only pages relevant to some intents in TREC Web track were collected

• For each page, 1 of 5 annotators hand-annotated hierarchical heading structure in its content body
  • Fleiss’ Kappa: .693 for headings and .583 for blocks
## Evaluation result (heading extraction)

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<tr>
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<th>Precision</th>
<th>Recall</th>
<th>F1-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decision tree learning [Okada, Arakawa]</td>
<td>.084</td>
<td>.884</td>
<td>.154</td>
</tr>
<tr>
<td>Naïve method based on tag names</td>
<td>.668</td>
<td>.320</td>
<td>.433</td>
</tr>
<tr>
<td><strong>Our method</strong></td>
<td><strong>.638</strong></td>
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  - Most test pages did not share visual style with training pages

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• The decision tree learning method did not work well
  • Most test pages did not share visual style with training pages
• Our method achieved a far better recall retaining about same precision as the naïve method

Evaluation result (block extraction)

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  • VIPS is complementary to our method

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• Our method: in accuracy close to heading extraction
  • Extracted blocks from actual headings by precision of .769

Conclusion

• Extraction of hierarchical heading structure is important for various applications of the web

• We proposed a method based on an idea that headings of the same level share their visual style

• Our method achieved high recall and satisfactory precision

• Our code and data sets will be available online
  • https://github.com/tmanabe