Analysis of the Folksonomy of Freesound

Frederic Font Corbera
CompMusic Meeting, July 12th 2012
What is Freesound?

- Online collaborative sound database
- People share audio clips under Creative Commons licenses
- Started in 2005 at the Music Technology Group
- The initial goal was to give support to sound researchers
- Has become one of the most popular audio clip sharing sites

Some quick numbers about Freesound (data from November 2011)

- 145,000+ sounds
- 2.5+ million users (~6,800 active contributors)
- ~30,000 unique visits per day
Outline

- one, collaborative-tagging, systems, basics, interesting, short
- 2. Folksonomy analysis
- 3. Tag-level characterization and conclusions
Part I:

one, collaborative-tagging, systems, basics, interesting, short
Collaborative tagging

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Collaborative tagging

- Community of users
- Tags
- Online resources

Tag application/Tag assignment
Collaborative tagging

Community of users

Tags

tag#1
>tag#2
>tag#3
>tag#4
>tag#5

Online resources

Folksonomy

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Collaborative tagging

- Describe any kind of content: music, sounds, photos, videos, user reviews, hyperlinks, metadata...

- Useful for organization and navigation of the content
  - Both at the system level and at the user level (users also use tags to “personally” organize internet content)

- Of special importance in online communities that share “multimedia” content

- Relevant research about collaborative tagging: general studies (2-5), user motivations and tag semantic classification (6-7), emerging communities/clusters in folksonomies (8-10).
Part II:

Folksonomy analysis
Folksonomy

Some big numbers...

- Annotations from April 2005 to March 2012
- 971,571 tag applications
- 6,802 tagging users
- 143,188 sounds (resources)
- 40,069 distinct tags (not necessarily semantically distinct)

- 6.79 tags per resource (average) - similar to Flickr, Bibsonomy and Delicious [10]
Typical “power law” like distribution (common in other folksonomies)
Indicates that a few tags are used a lot and that many tags are rarely used

Read like: probability that a tag occurs at least # times
# 20 most used tags

<table>
<thead>
<tr>
<th>#</th>
<th>Tag</th>
<th>Occ.</th>
<th>#</th>
<th>Tag</th>
<th>Occ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>field-recording</td>
<td>14954</td>
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<td>velocity</td>
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<td>5261</td>
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<td>4</td>
<td>noise</td>
<td>9866</td>
<td>14</td>
<td>drone</td>
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<td>5</td>
<td>loop</td>
<td>9015</td>
<td>15</td>
<td>l-shot</td>
<td>4877</td>
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<td>processed</td>
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<td>7</td>
<td>ambient</td>
<td>7707</td>
<td>17</td>
<td>soundscape</td>
<td>4619</td>
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<tr>
<td>8</td>
<td>electronic</td>
<td>6671</td>
<td>18</td>
<td>metal</td>
<td>4546</td>
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<tr>
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<td>synth</td>
<td>6633</td>
<td>19</td>
<td>water</td>
<td>4355</td>
</tr>
<tr>
<td>10</td>
<td>percussion</td>
<td>5574</td>
<td>20</td>
<td>ambience</td>
<td>4240</td>
</tr>
</tbody>
</table>

- Quite “general” concepts
Tag applications per user

- Number of users that have generated a particular number of tag applications.
- Most of the users perform only a few tag applications.
- Correlation between size of user’s vocabulary and number of uploaded sounds is positive (0.52). Users use new tags as they upload new sounds <- diversity?
Tag growth
New tags per month
New tags per month

Freesound “2”
New tags, new users (cumulative)

- Correlation is 0.99 (normalizing by total number of tags/users)
- As new users are being registered, new tags are being created + tag growth without signs of stability <- users tagging in isolated fashion, no tag sharing/reuse...
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• As new users are being registered, new tags are being created + tag growth without signs of stability
  <- users tagging in isolated fashion, no tag sharing/reuse...
Tag reuse
Tag reuse

- Simple metric for tag reuse: percentage of tag applications that involve already used tags

\[ p = 100 \frac{M - N}{M}, \]

where \( M \) is the total number of tag applications and \( N \) is the total number of distinct tags.

- \( p = 95.88\% \), vast majority of tag applications involve reused tags
Another metric for tag reuse “across users”: average number of users that have used each tag

\[ r = \sum \frac{U_t}{T}, \]

where \( T \) is the total number of distinct tags (size of the vocabulary) and \( U_t \) is the total number of distinct users that have used tag \( t \).

- \( r = 1 \) means that every tag is only used by one user (no reuse at all)
- \( r = 4.84 \), higher than CiteULike and MovieLens folksonomies [2,16], but quite low
Tag reuse

- Tag reuse from **users personal vocabulary** (average tags that users reuse from their vocabulary)

\[ k = \frac{\sum T_{ru}}{U}, \]

where \( U \) is the total number of users and \( T_{ru} \) is the number of tags from the vocabulary of user \( u \) that have been reused (by \( u \)).

- \( k = 11.41 \), higher than CiteULike and MovieLens folksonomies [2,16]
- Considering that average vocabulary size per user is 28.49, users tend to reuse 1/3 of their tags
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**SO…**

- No vocabulary size stabilization, low general reuse across users <- no reuse...
- But 95.88% of tag applications involve already used tags <- ?
Tag reuse

- Number of tags that have been reused a particular number of times

Read like: 
# of tags than have been reused # times
Tag reuse

- Number of tags that have been reused a particular number of times
- Only a small part of the tagging vocabulary is being reused (the most popular tags), and these are being reused a lot < no real vocabulary sharing among users, semi-agreement on general concepts to describe sounds but not in details… actually, Freesound tagging interface does not promote reuse (no tagging recommendation, not showing most used tags…)
Tag semantic classification
Follow methodology in [7] (Cantador et al.)

Classify tags for their semantic utility:
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1) **content**: tags that describe the content of the sound such as instruments or sound sources that appear
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3) **subjective**: related to subjective opinions of the users that tagged the resource
Tag semantic classification

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  2) **context:** tags that refer to the location of the recording or the action that generated the sound

  3) **subjective:** related to subjective opinions of the users that tagged the resource

  4) **organizational:** tags useful for users personal organization
Tag semantic classification

Figure from [7]
Tag semantic classification

More tags for content and context categories than for the others (meaningful for all users, not personal tagging)

Nevertheless, method produces a lot of ambiguous categorizations <- further research

The external knowledge base (YAGO) probably lacks domain-specific concepts

<table>
<thead>
<tr>
<th>Category</th>
<th>Num.</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>17,172</td>
<td>laugh, drum-beat, service-bell, folk-guitar, sitar, nice-music</td>
</tr>
<tr>
<td>Context</td>
<td>8,224</td>
<td>playground, mid-night, patagonia, studio-recording, barcelona</td>
</tr>
<tr>
<td>Subjective</td>
<td>3,962</td>
<td>oh-may-youre-so-beautiful, psychological, realistic, stressful</td>
</tr>
<tr>
<td>Organizational</td>
<td>830</td>
<td>i-love-calculus, sound-of-string, open-air-party, sonsdebarcelona-ester</td>
</tr>
<tr>
<td>None</td>
<td>17,772</td>
<td>AKGC1000s, mouvement, 60bpm, pasillo, orchestra, grabaciones-de-campo</td>
</tr>
</tbody>
</table>

Table 2. Semantic categorization of Freesound tags.
Tag clusterization
Tag clusterization

- Extract clusters of semantically related tags (used for particular kinds of sounds, ...)
- Based on two graph clustering techniques:
  - “Standard” modularity optimization - Blondel et al. [12]
  - Hybrid graph-based clusterization (HGC) - Papadopoulos et al. [10]

- We represent the folksonomy as a tripartite hypergraph and extract a tag-tag network where nodes are tags and edges represent similarity between tags (details on the process can be found in [18]). Tag similarity is based in tag co-occurrence in sounds.
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- Needs more research, but lets see some examples...
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<thead>
<tr>
<th>#</th>
<th>Size</th>
<th>Tags of the cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>777</td>
<td>field-recording, noise, ambient, soundscape, ambience, sound, atmosphere, birds, nature, ambiance, people, wind, talk, recording, car, city, street, engine, speak, woman</td>
</tr>
<tr>
<td>2</td>
<td>539</td>
<td>bass, guitar, techno, distortion, distorted, trance, drumloop, chord, bpm, free, delay, multi-sample, synthesis, lead, rock, dubstep, synthesized, dub, clean, hop</td>
</tr>
<tr>
<td>3</td>
<td>433</td>
<td>door, footsteps, open, walking, squeak, paper, scratch, household, scrape, floor, steps, walk, UPF-CS12, slide, creak, opening, closing, light, running, concrete</td>
</tr>
<tr>
<td>4</td>
<td>372</td>
<td>Synth, Water, Background, Effect, Soundscape, VST, Summer, Echo, Sub, Drum, Bass, Door, pull, Metal, Noise, Field-recording, Field-Recording, Click, FX, Ambient</td>
</tr>
<tr>
<td>5</td>
<td>348</td>
<td>kitchen, pop, fire, natural, snap, crack, crunch, crackle, aip09, up, bounce, ding, warm, blow, rubber, body, eating, mouth, bowl, balloon</td>
</tr>
<tr>
<td>6</td>
<td>341</td>
<td>train, announcement, station, heavy, bang, rumble, high, automated, road, clang, airport, jingle, rotterdam, stop, thump, ride, subway, passing, railway, steam</td>
</tr>
<tr>
<td>7</td>
<td>330</td>
<td>drum, loop, percussion, velocity, snare, 1-shot, metal, water, beat, sample, drums, hit, music, industrial, wood, hard, reverb, weird, dance, echo</td>
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<tr>
<td>8</td>
<td>324</td>
<td>synth, drone, fx, male, acoustic, effect, human, horror, electric, dark, sci-fi, bell, deep, house, synthesizer, computer, metallic, game, cinematic, sound-design</td>
</tr>
<tr>
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<td>305</td>
<td>voices, barcelona, poznan, poland, freesound, image, japan, applause, h4n, seoul, korea, hall, clapping, performance, money, coin, ghent, japanese, desk, coins</td>
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<td>electronic, electro, analog, digital, speech, english, radio, low, samples, beep, wave, tone, circuit, static, fm, plane, pulse, military, army, clip</td>
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<tr>
<td>11</td>
<td>265</td>
<td>click, synthetic, foley, switch, button, effects, soundequeffect, strange, granular, press, abstract, dj, vintage, hi-tech, bleep, sounddesign, virus, sweep, ti, funk</td>
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<tr>
<td>12</td>
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<td>multisample, pad, artificial, evolving, sax, strings, mezzoforte, violin, woodwind, jazz, zoom-h2n, saxophone, 120bpm, divine, non-vibrato, vst, chordophone, ppg, sampled-instruments, classical</td>
</tr>
<tr>
<td>13</td>
<td>288</td>
<td>buzz, animal, jungle, ice, south-spain, insects, snow, zoo, animals, tropical, france, waterfall, insect, cricket, exotic, fly, farm, horse, donana, rainforest</td>
</tr>
</tbody>
</table>

Table 3. Most popular tags of the biggest clusters that emerge using the standard modularity optimization technique. “Size” indicates the total number of tags of each cluster.
With modularity optimization... the Folksonomy of Freesound
Frederic Font Corbera
CompMusic Meeting, July 12th 2012

"Field recordings"

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<td>overtones, tabla, iran, zarb, hindustani, tambura, carnatic, middle, emotion, sitar, tanpura, bol, indian-classical, compmusic, tonic, raga, kanjira, harmonium, ganjira, eastern [8 more]</td>
</tr>
<tr>
<td>2</td>
<td>26</td>
<td>communication, bip, ham, bips, tuner, navigation, radio-static, receiver, telecommunication, interferences, vhf, ham-radio, sw, cb, fm-receiver, vhf-receiver, uhf, uhf-receiver, tv-tuner, cable-tuner [6 more]</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>distorted-guitar, guitar-chords, rhythm-guitar, strummed, ukulele, strumming, single-notes, 160bpm, power-chord, miscellaneous, lead-guitar, guitar-notes, uke, extras, drop-d, les-paul, 96khz, ukelele, 01, room-mic</td>
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<tr>
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<td>pipe-organ, carousel, efteling, funfair, wurlitzer, street-organ, live-music, mechanical-music, 200a, e-piano, barrel-organ, parish-fair, annual, leisure, carousel, parish-fair-organ, hurdy-gurdy, funfair-organ, historic-organ, merry-go-round</td>
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<td>5</td>
<td>15</td>
<td>monk, tuva, yoga, undertone, mongolian, puja, tantric, umzie, tuvan, khumi, tantra, gyuto, yogic, kargyraa, sygty</td>
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<td>12</td>
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Table 4. Most popular tags of the smallest clusters that emerge using the HGC technique.
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### Tags of the cluster

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"Keyboards"
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Table 4. Most popular tags of the smallest clusters that emerge using the HGC technique.

“Frightening sounds”
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Table 4. Most popular tags of the smallest clusters that emerge using the HGC technique.
Part III: Tag-level characterization and conclusions
Tag: sitar
********************
Tag discrimination 0.034%
Probability of being used at least 1 times per month in the future 0.169
Number of occurrences: 49
Occurrences per day: 0.019
Number of distinct users using the tag (reuse): 25
Semantic classification: u'content'
Main cluster: miscellaneous

Tag: guitar
********************
Tag discrimination 2.770%
Probability of being used at least 1 times per month in the future 0.978
Number of occurrences: 3967
Occurrences per day: 1.496
Number of distinct users using the tag (reuse): 422
Semantic classification: u'content'
Related tags: None
Main cluster: music
Tag: barks
*****************
Tag discrimination 0.011%
Probability of being used at least 1 times per month in the future 0.004
Number of occurrences: 16
Occurrences per day: 0.010
Number of distinct users using the tag (reuse): 12
Semantic classification:
Related tags: None
Main cluster: field recordings

Tag: spring
*****************
Tag discrimination 0.754%
Probability of being used at least 1 times per month in the future 0.923
Number of occurrences: 1080
Occurrences per day: 0.409
Number of distinct users using the tag (reuse): 149
Semantic classification: u'content', u'context'
Related tags: 'field-recording', 'noise', 'drone', 'birds', 'music', 'nature', 'people', 'wind', 'car', 'bird', 'traffic', 'sounds', 'rattle', 'cars', 'park'
Main cluster: field recordings
Tag-level characterization (idea)

Tag: glitch
************************
Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Tag: glitch

Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Tag: glitch

*****************
Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Tag: glitch

Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Related tags: None
Tag: glitch

Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Related tags: None
Main cluster: effects
Tag: glitch

Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: 'content'
Related tags: None
Main cluster: effects

Tag: people
Tag: glitch

*************************
Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Related tags: None
Main cluster: effects

Tag: people

*************************
Tag: glitch
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Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Related tags: None
Main cluster: effects

Tag: people
*****************
Tag discrimination 1.574%
Tag: glitch
*****************
Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Related tags: None
Main cluster: effects

Tag: people
*****************
Tag discrimination 1.574%
Probability of being used at least 1 times per month in the future 0.962
Tag: glitch

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Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Related tags: None
Main cluster: effects

Tag: people

*****************
Tag discrimination 1.574%
Probability of being used at least 1 times per month in the future 0.962
Number of occurrences: 2254
Tag: glitch
**************************
Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: 'content'
Related tags: None
Main cluster: effects

Tag: people
**************************
Tag discrimination 1.574%
Probability of being used at least 1 times per month in the future 0.962
Number of occurrences: 2254
Occurrences per day: 0.850
Tag: glitch
************************
Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Related tags: None
Main cluster: effects

Tag: people
************************
Tag discrimination 1.574%
Probability of being used at least 1 times per month in the future 0.962
Number of occurrences: 2254
Occurrences per day: 0.850
Number of distinct users using the tag (reuse): 317
Tag: glitch

Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
Occurrences per day: 1.406
Number of distinct users using the tag (reuse): 262
Semantic classification: u'content'
Related tags: None
Main cluster: effects

Tag: people

Tag discrimination 1.574%
Probability of being used at least 1 times per month in the future 0.962
Number of occurrences: 2254
Occurrences per day: 0.850
Number of distinct users using the tag (reuse): 317
Semantic classification: u'content', u'context'
Tag: glitch
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Tag discrimination 2.597%
Probability of being used at least 1 times per month in the future 0.977
Number of occurrences: 3719
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Number of occurrences: 2254
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Number of distinct users using the tag (reuse): 317
Semantic classification: u'content', u'context'
Related tags: 'field-recording', 'noise', 'drone', 'birds', 'music', 'nature', 'wind', 'car', 'bird', 'traffic', 'spring', 'sounds', 'rattle', 'cars', 'park'
Tag-level characterization (idea)

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Related tags: 'field-recording', 'noise', 'drone', 'birds', 'music', 'nature', 'wind', 'car', 'bird', 'traffic', 'spring', 'sounds', 'rattle', 'cars', 'park'
Main cluster: field recordings
Conclusions

- Freesound Folksonomy is continuously growing and there are no signs of stabilization.
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- One of the reasons for this continuous growth might be that new kinds of content are being uploaded that require new concepts to describe them.
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- As a result: very noisy -> synonymy, polysemy, misspellings and other problems...
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- Hard to extract “structured” information like semantic classification or tag clusterization, although our attempt was able to identify some interesting things.
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- **Domain-specific knowledge is needed** to better understand the folksonomy, tag meanings, and be able to improve sound descriptions.
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- Some of the characterization metrics from these analysis can be useful for a tag recommendation system.
References


References II


Questions?

Frederic Font Corbera
CompMusic Meeting, July 12th 2012
Blondel et al (2008) - Modularity optimization


Initial step: each node is assigned a different cluster (so there are as clusters as nodes in the graph)

1 - For each node \( i \):
   - Consider all neighbors \( j \) of \( i \) and evaluate the increase in modularity if \( i \) is assigned to the communities of each one of the neighbors.

The modularity of a partition is a scalar value between -1 and 1 that measures the density of links inside communities as compared to links between communities. Defined as:

\[
Q = \frac{1}{2m} \sum_{i,j} \left[ A_{ij} - \frac{k_i k_j}{2m} \right] \delta(c_i, c_j),
\]

where \( A_{ij} \) represents the weight of the edge between \( i \) and \( j \), \( k_i = \sum_j A_{ij} \) is the sum of the weights of the edges attached to vertex \( i \), \( c_i \) is the community to which vertex \( i \) is assigned, the \( \delta \)-function \( \delta(u, v) \) is 1 if \( u = v \) and 0 otherwise and \( m = \frac{1}{2} \sum_{ij} A_{ij} \).

Used as a way to evaluate **quality of partitions** of a clustering technique. Also used as an objective function to **optimize** for clustering algorithms.

2 - If there is positive gain, assign \( i \) to the community of \( j \) that has the biggest increase.

**iterate** until modularity does not increase when moving any node

+ Simple, **Fast**
- Tendency to form big clusters, **do not** allow node overlapping
  +/− No parameters (modularity increase?)

C++ code: [https://sites.google.com/site/findcommunities/](https://sites.google.com/site/findcommunities/)

Initial step: determine a number of cluster “seeds” which are groups of nodes. This is done by finding the nodes that satisfy a certain condition regarding the number of neighbors \( u \) above a certain threshold \( e \) of structural similarity. \( u \) and \( e \) are determined automatically with a parameter exploration step.

1 - Consider the neighbors of all nodes from the seed (which are not already part of the seed) and compute a simplified modularity measure defined as

\[
M(S) = \frac{\text{ind}(S)}{\text{outd}(S)} = \frac{|\{(v, w) \in E|v, w \in S\}|}{|\{(v, w) \in E|v \in S \land w \in V - S\}|}
\]  

(3)

where \( \text{ind}(S) \) is the number of edges connecting nodes inside the seed (plus the current neighbor) and \( \text{outd}(S) \) is the number of edges connecting with nodes outside the seed (plus the current neighbor).

2 - Expand the seed by adding all neighbors that produce an increase of \( M \).

iterate until modularity does not increase when adding any node

\(+/-\) No parameters
+ Allows node overlapping (due to expansion step)
- Tendency to form “repeated” clusters

java code: kindly offered by the author if contacted