Visualizing World University Rankings: A Novel Algorithm

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Abstract

The ranking of different universities the world over has always been a topic of great interest. Rankings are used by students to find the best university for their studies, by faculty to choose the right university to teach, and, by university administrators in their decision making. However, rankings in the form of scores are hard to comprehend and are rather drab. In today's tech savvy world, a pie chart or a histogram would not warrant even a cursory glance on a search engine. There is a need to represent data in a more understandable visual format-this is a completely non-trivial enterprise and subsumes technical knowledge from across three intellectual domains-information technology, computer graphics and educational technology. In particular, the application demonstrated in this paper uses aggregation algorithms, z-scores and cumulative probability scores to grade and visualize data. The evaluation criteria include indicators such as teaching and learning, research productivity, publications and patents, employability, regional outreach and multiculturalism amongst many others. To our knowledge, this first analysis yields visualizations with clarity and insight, far superior to the usual sunburst diagrams used by most multiranking systems. This application is further being customized so that it is easily downloadable as a user friendly applet. To our knowledge, this has not been done before in the field of Educational Technology.

1. Introduction

Ranking methodologies can never be a perfect representation of the quality of an institution. It is only meant to be used as a guideline for students, faculty and the university administration. At the same time, they provide valuable insight into where a student is placed among his/her competitors around the world, which universities provide the best career prospects for teaching staff, and in which fields a university is lacking. The essence of these rankings lies in the aggregation of data provided by a large number of universities all around the world. Thus, there is a need to quickly grasp the required information from the data without having to perform tediouscalculations. Graphical representation of the information will thus be ideal to quickly assess a university in different fields of study.

2. Current Scenario

Over the years, different organizations have attempted to rank the universities of the world. 3 of them have now emerged as globally accepted rankings – The QS World University Rankings (QS), The Times Higher Education World University Rankings (THE) and the Academic Ranking of World Universities (ARWU).

The QS World University Rankings currently considers over 2000 and evaluates over 700 universities in the world, ranking the top 400.

The ranking criterion used by QS is[4]:

- Academic Reputation – 40%
- Employer Reputation – 10%
- Citations per Faculty – 20%
- Faculty-student Ratio – 20%
- Proportion of International Students – 5%
- Proportion of International Faculty – 5%

Times Higher Education created a new ranking methodology with Thomson Reuters, published as Times Higher Education World University Rankings. It uses 13 performance indicators, which are then grouped into 5 broad areas. The 5 areas of classification as of October 2012 are[5]:

- Teaching: the learning environment – 30%
- Research: volume, income and reputation – 30%
- Citations: research influence – 30%
- Industry income: innovation – 2.5%
- International outlook: staff, students and research – 7.5%

The Academic Ranking of World Universities (ARWU) was first published in June 2003 by the Center for World-Class Universities (CWCU), Graduate School of Education (formerly the Institute of Higher Education) of Shanghai Jiao Tong University, China. ARWU uses six objective indicators to rank world universities, which are[1]:

- Alumni of an institution winning Nobel Prizes and Fields Medals – 10%
- Staff of an institution winning Nobel Prizes and Fields Medals – 20%
- Highly cited researchers in 21 broad subject categories – 20%
- Papers published in Nature and Science – 20%

- Papers indexed in Science Citation Index-expanded and Social Science Citation Index – 20%
- Per capita academic performance of an institution – 10%

3. Need for Alternative Ranking Systems

The "Berlin Principles" published in the IHEP (Institute for Higher Education Policy) was independently derived by an ad hoc group of analysts and ranking entities known as the International Rankings Expert Group (IREG).It was released in May 2006 to wide acclaim.

According to the Berlin Principles[3], rankings should

"Be clear about their purpose and their target groups. Rankings have to be designed with due regard to their purpose. Indicators designed to meet a particular objective or to inform one target group may not be adequate for different purposes or target groups."

Taking this principle of good ranking practice seriously means that defined rankings should include and compare similar and comparable programmes or institutions in terms of their missions and profiles. There is no one-size-fits-all-approach for rankings. It does not make sense to compare study programmes, say, in engineering in a small regional-oriented institution focusing on undergraduate education with an internationally oriented research university where graduate education (Master, PhD) is a central element of the profile.

The QS ranking has been criticized for relying too heavily on anonymous feedback reviews for their academic reputation scores, which constitutes 40% of the total score.

THE puts less emphasis on reputation and heritage and instead looks at harder measures of excellence like research, teaching and knowledge transfer. The increased emphasis on teaching, which is a very subjective aspect, creates a new point of unreliability.

By the ARWU ranking methodology, almost 90% of a university's score is a reflection of its research undertaking. Thisseems to be a rather narrow criterion for ranking. These rankingcomponents undervalue some universities, particularly those strong in arts and humanities, as these subject fields are not research oriented.

Thus, it is clear that a paradigm shift is needed in the way universities are understood to impart knowledge and life skills to students. Using common measures to rank universities, regardless of their areas of focus and style of teaching, is not the right strategy to truly understand where they stand.

4. U-Multirank

On 2 June 2009 the European Commission announced the launch of a feasibility study to develop a multi-dimensional global university ranking. Its aims were to be [2]:

- Multi-dimensional: Covering the various missions of institutions, such as education, research, innovation, internationalization, and community outreach.

- Transparent: it should provide users with a clear understanding of all the factors used to measure performance and offer them the possibility to consult the ranking according to their needs.

- Global: covering institutions inside and outside Europe (in particular those in the US, Asia and Australia).

U-Multirankdeveloped a new international ranking instrument that is user-driven, multi-dimensional and methodologically robust on the basis of a carefully selected set of design principles. This new on-line instrument enables its users first to identify institutions that are sufficiently comparable to be ranked and, second, to design a personalised ranking by selecting the indicators of particular relevance to them. U-Multirank enables such comparisons to be made both at the level of institutions as a whole and in the broad disciplinary fields in which they are active.

The developed tool takes the name 'U-Multirank' as it stresses three fundamental points of departure:

- It is multi-dimensional, recognizing that higher education institutions serve multiple purposes and perform a range of different activities.
- It is a ranking of university performances (although not in the sense of an aggregated league table like other global rankings).
- It is user-driven (as a stakeholder with particular interests, you are enabled to rank institutions with comparable profiles according to the criteria important to you).

U-Multirank includes a range of indicators that will enable users to compare the performance of institutions across five dimensions of higher education and research activities:

- Teaching and learning
- Research
- Knowledge transfer
- International orientation
- Regional engagement

On the basis of data gathered on these indicators across the five performance dimensions, U-Multirank could provide its users with the on-line functionality to create two general types of rankings:

- Focused institutional ranking
- Field based ranking

4.1 Focused institutional ranking

U-Multirank believes that a focused institutional ranking relates to a particular dimension of the classification and allows comparisons of institutions along a single aspect of institutional activity. According to its multidimensional approach, a focused ranking does not collapse all dimensions into onesingle rank, but will instead provide a fair picture of institutions ('zooming in') within the multi-dimensional context provided by the full set of dimensions. Thus, multiple viewpoints of a higher education institution may be presented—viewpoints that bear relevance to the various users of the classification, for instance academics, students, administrators, policy-makers on various levels, providers of funding, business leaders, researchers, or the general public. The implication of this approach is that institutions can be expected to have different comparative results on different dimensions and thus that a multi-

dimensional institutional ranking approach implies different outcomes for different institutions on different dimensions.

Individual institutions can of course be expected to 'score' differently on different dimensions. The set of the 'scores' of an individual institution on the whole set of dimensions of the classification defines the institution's profile.
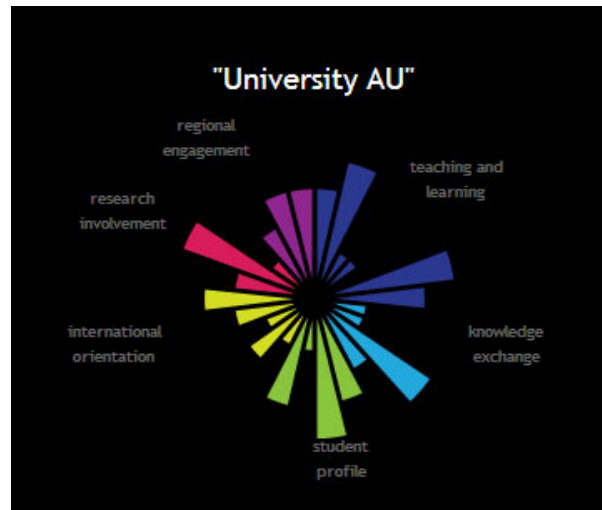

Fig 1. Sunburst Diagrams–Focused Institutional Ranking Visualizations used by U-Multirank

4.2 Field based ranking

A field-based ranking is a multi-dimensional ranking of a set of study programmes in a specific field or discipline of higher education. Rankings of study programmes can only be meaningfully interpreted within the wider context provided by the multi-dimensional classification of entire institutions.

U-Multirank provides visualizations of university performance in the form of 'Sunburst Diagrams' at the institutional level and 'field tables' at the field level. In the sunburst diagrams, the performance on all indicators at the institutional level is represented by the size of the rays of the 'sun'. A larger ray means a higher performance on that indicator. The color of a ray reflects the field to which it belongs.

Personalised ranking

	international academic staff	research publication	doctorate productivity	student internships in	CPD courses offered
Institution 8	green	yellow	yellow	yellow	yellow
Institution 1	green	-	-	yellow	green
Institution 3	green	green	green	yellow	green
Institution 9	green	red	red	yellow	red
Institution 7	yellow	yellow	red	yellow	yellow
Institution 5	yellow	green	green	red	yellow
Institution 2	red	yellow	yellow	yellow	red
Institution 6	red	red	yellow	red	yellow

Fig 2. Tabular approach to Field Based Rankings used by U-Multirank

The visualizations however were found to have a few crucial drawbacks. The sunburst diagram, for example, had the following shortcomings:

- The sectors of the sunburst diagram did not accurately represent their respective scores. Different scores that varied by small amounts were found to 'snap' to a specific sector length, giving the appearance that they are all the same value.
- Universities with a score of zero in a certain field were shown to have a certain minimum score in that field. This was quite misleading.

As for the field based representation:

- The table format is cluttered and does not provide a clean and intuitive visualization of the data
- Institutions are categorized into 3 groups marked by green, yellow and red. Although this does give a general idea of the performance of an institution, it abstracts away a lot of details about the extent to which a university excels.

5 Our Novel Visualisation:

Thus, it became immediately clear that a new form of visualization is required to do full justice to the high quality data compiled by U-Multirank. In keeping with the aims of U-Multirank, two forms of visualization were developed, one each for Focused Institutional Rankings and Field Based Rankings. They were developed from scratch keeping in mind the defects of U-Multirank's visualizations. Creation of clear and concise graphics was the topmost priority for the design of the application.

5.1 Focused Institutional Rankings (StarChart)

In order to provide detailed information for a single university, we implemented a starchartvisualization as opposed to the sunburst diagram used by U-Multirank. The star chart allows for a detailed overview of the performance of a university in a similar way to the sunburst diagram. However, instead of providing all the details in one chart, the information is split into two dynamic graphs. While the starchart

provides aggregate scores of a university in a major field, the bargraph allows for detailed scrutiny of the data, shedding light on what components affect the score of that university in that field.
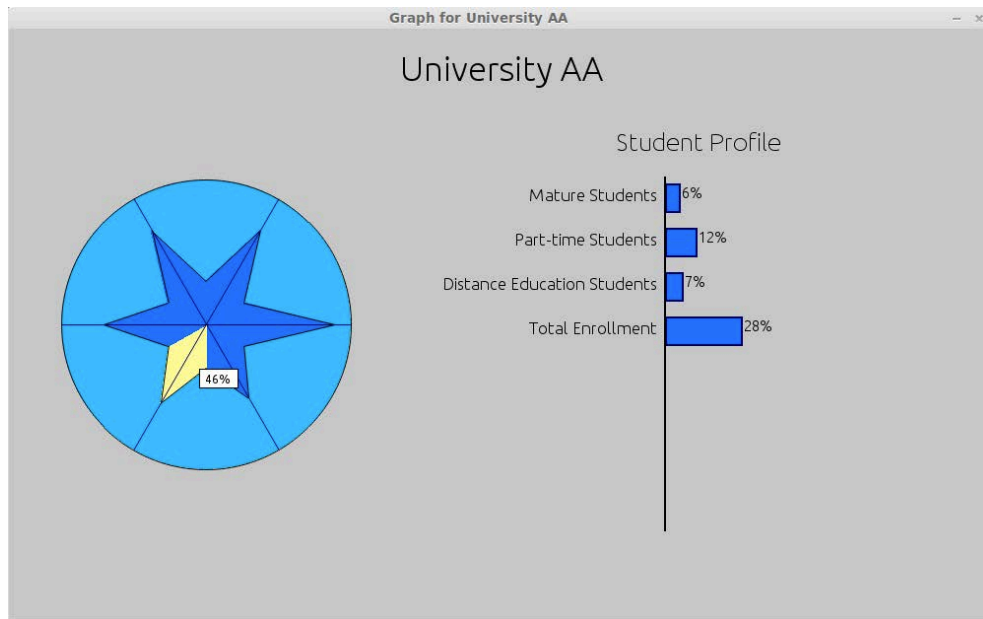

Fig 3. Star chart of a university providing in-depth information of its Student Profile. The Star on the left shows the aggregate score in the field while the bar graph shows the constituents of that score.

5.2 Field Based Rankings (Bar Graph):

In order to visualize field based rankings (relative performance of all universities in a particular field of interest), we chose a bar graph representation in place of the tabular representation used by U-Multirank. Bargraphs allow for comparison between universities to a much finer degree. The extent by which a university is ahead or behind others is very intuitively conveyed using bargraphs, whereas this information is completely hidden in tabular representations. The bargraph was designed to dynamically provide additional text information about each university (brief descriptions, QS ranks etc.), augmenting the information gained from the graph itself. Additionally, the application allows for the color of the bar to be changed to represent further information. In Fig 3. Below, a gray shade is used to represent universities that have been ranked by QS.
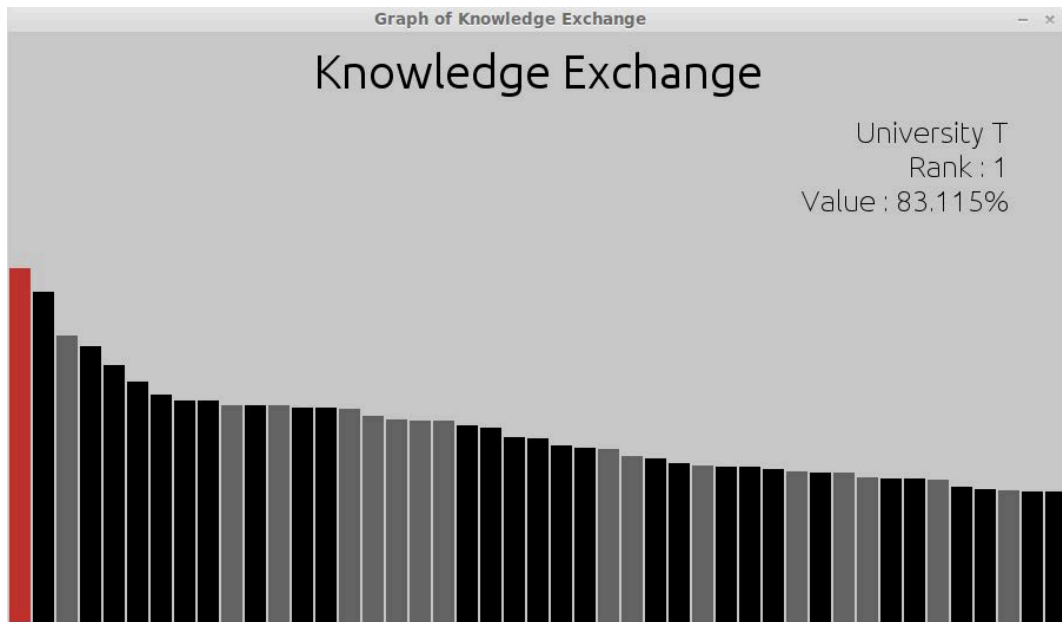
Fig 4. Bar graph of knowledge exchange. Each bar represents a university. It can be seen that the first two universities are significantly ahead of the competition. In the tabular representation of U-Multirank, the first 10 universities would all be colored green.

6 Conclusion

The new visualizations provide a stunning graphical representation of the data, throwing light on aspects that were not visible with those provided by U-Multirank. The core of the U-Multirank philosophy, the Multi-dimensional approach to ranking, provides a new perspective to university performance. This is clearly depicted by the visualizations.
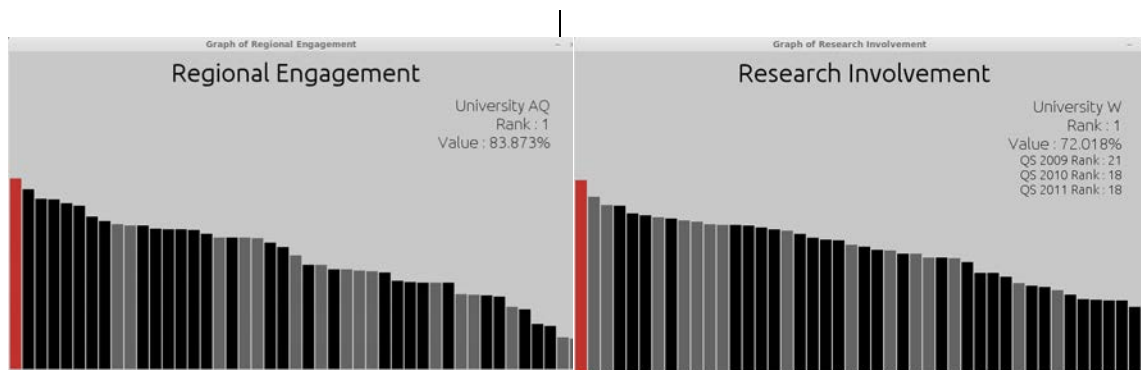

Fig 5. Bar graphs showing performance of universities in two fields – Regional Engagement and Research Involvement. The gray bars represent those universities that have been ranked by QS.

Fig. 5 Above depicts an interesting contrast. Universities ranked by QS (having gray colored bars) are predominantly on the higher range of the graph of Research Involvement (Right), whereas the graph of Regional Engagement has only 2 QS ranked universities within the top 10.

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