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Curricula of HCI and Computer Graphics: From theory to practice

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ABSTRACT

The last few years have seen the spectacular evolution and spread of computer applications, supported by technologies such as internet, wireless networks and mobile devices. User interfaces help people to easily access, understand, and process information. User interfaces depend on two relatively new fields: Human-Computer Interaction (HCI) and Computer Graphics (CG). These domains evolved continually to accompany the new generations of computer applications. They are an essential part of every computer system and therefore, they should have an important part in informatics education. However, their integration in world-wide degrees differs significantly from program to program. The aim of this paper is twofold: first, we present and discuss two reference curriculum proposals. Second, we conduct a case study to index several European masters programs using the reference curriculum to see to what extent the practice reflects the theory. We have developed a web portal to collect and analyse information about master programs, and to present several graphical overviews of these data. By providing these resources through a web site, we hope to contribute to enhance computer graphics and human computer interaction visibility in computer-science education in a global context.

Keywords: Curriculum, Bachelor, Master, Computer Graphics, Human Computer Interaction

1. INTRODUCTION

The last few years have seen the spectacular evolution and spread of computer applications, supported by technologies such as internet, wireless networks and mobile devices. User interfaces help people to easily access, understand, and process information. In addition, computing generalisation implies that applications are used in varied contexts by a very large public. Therefore, novel users interfaces taking into account complex user's profiles, interaction contexts and multimodal information, must be designed and developed.

User interfaces depend on two relatively new fields: Human-Computer Interaction (HCI) and Computer Graphics. These domains evolved continually to accompany the new generations of computer applications. They are an essential part of every computer system and therefore, they should have an important part in informatics education. However, their integration in world-wide degrees differs significantly from program to program.

In this paper we first describe briefly the structure of higher education in Europe. We then presents an analysis and comparison of curricula for Computer Graphics and HCI fields. We build on these curricula and more

specifically on their associated knowledge bases to index computer programs. This indexing is further used to automatically generate two types of graphical overviews: conceptual maps and geographical maps. By providing these resources through a web site, we hope to contribute to enhance computer graphics and human computer interaction visibility in computer-science education. In turn we hope that this effort will further facilitate: (1) readability and comparison of University programs, (2) cross-university transfers and cooperation as well as (3) the evolution of ongoing curricula developments in these fields.

2. STRUCTURE OF HIGHER EDUCATION IN EUROPE

Since Bologna meeting in 1999, countries and education institutions in Europe are engaged in a process of change to create a common European Higher Education Area (EHEA) by 2010. The Bologna Process introduces a three cycle study system consisting of two basic cycles, Bachelor and Master, and then a third research-oriented cycle, Doctoral degree. It also introduces the European Credit Transfer System (ECTS), which quantifies the student's workload required to achieve the objectives of a programme (1 year of study equals 60 credits). Bologne Process reforms seek to developed an EHEA that will facilitate mobility of students and researchers, improve european cooperation and allow understanding, comparability and recognition of degrees.

Bachelor/Master system establishes a study structure which allows students to pursue graduate studies or employment. Furthermore, this system is internationaly compatible and thus, reduces obstacles to mobility. 180 ECTS credits are required for the European Bachelor's degree. Master's degree are open to students who already have a Bachelor's degree or equivalent diploma. A Master program last a minimum of one year, during which the student must accumulate 60 to 120 credits, depending on school entry requirements. Currently, education institutes in Europe are restructuring their programs to implement the Bologna Bachelor/Master system (figure 1).

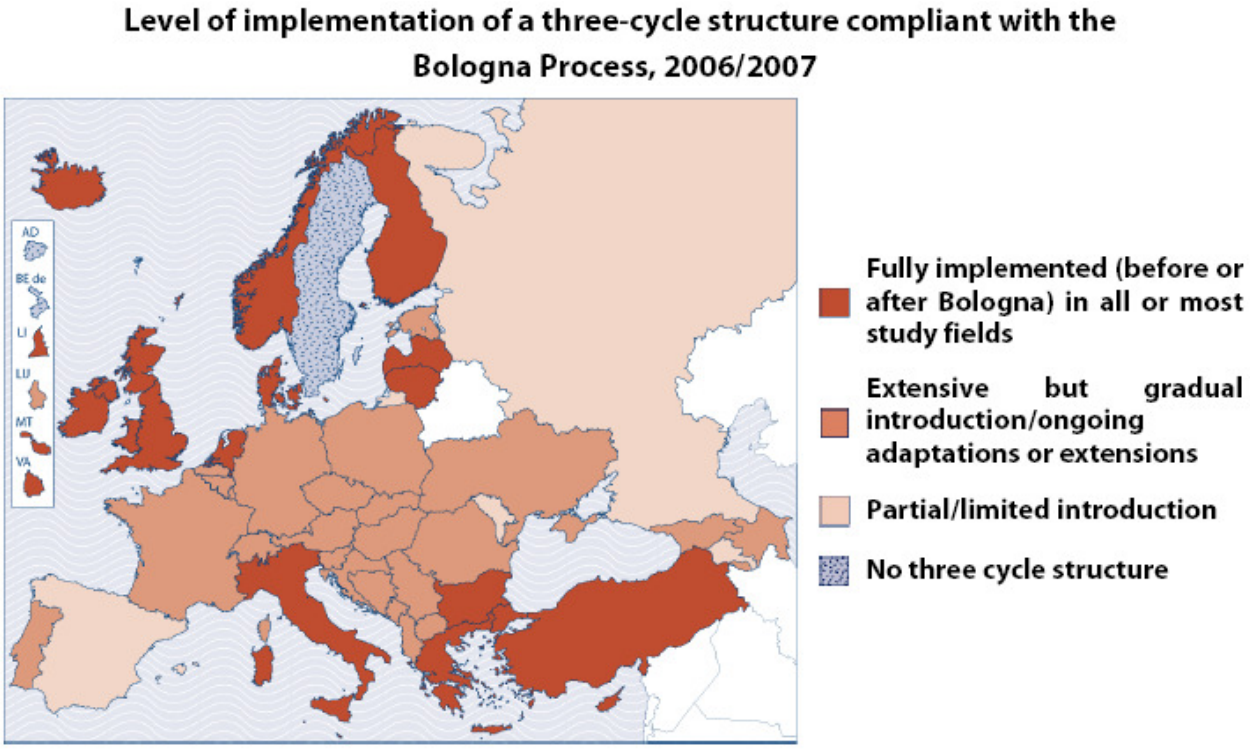

Figure 1. Bachelor/Master system implementation in Europe (©Eurydice)

The most recent Bologna Process conference [London communiqué], underline the considerable interest that has provoked the Bologna reforms between European and international partners, mainly to extent the recognition of qualifications and then, to be able to understand anywhere a student's credentials. They also state that the curricula reform must lead to "qualifications better suited both to the needs of the labour market and to further study". These two aspects are directly traited in this paper : the main concern of our study is to analyse HCI/Computer Graphics Master curricula in Europe to enhance visibility of these programs in an global context.

3. COMPUTER GRAPHICS AND HCI CURRICULUM : THE THEORY

A genuine curriculum covers several dimensions of education including "knowledge oriented" definitions of key concepts of the field, decomposition into courses, etc. Over the past decades, several initiatives brought new insights into the design of curricula for Computer Graphics and HCI. We intend to build upon existing work and in particular upon most recent results. These results further help us in drawing a comparison and generating graphical overviews of a selected set of actual programs that can be found in Europe and LatinAmerica. In turn, we hope that such an overview of how these curricula are represented amongst real programs can help in updating and developing these curricula..

SIGGRAPH AND EUROGRAPHICS CURRICULA

The curriculum (Bertoline, 2001) for computer graphics is described through a knowledge base. This knowledge base is the result of almost 10 years of an ongoing effort of computer graphics community to define the skills and concepts that "every computer graphics student should have some exposure to and with which every instructor ought to have some familiarity".

The current result is the knowledge based defined in 2006 where seventeen broad heading are presented containing many sub-headings and details that can be found in (Laxer ,2006). Even though the base is not exhaustive it covers the basis of an interdisciplinary curriculum in computer graphics. The reason for the seventeen broad heading is that it includes the characterisation of background knowledge of other fields required in the computer graphics field: physical sciences for considerations concerning lighting, detection collision of more general laws on motion, etc. It is important to stress that HCI is one of the seventeen broad heading. Yet it is the only category that the authors did no detail at all. This is very understandable due to the very nature of the relationships between HCI and Computer Graphics: these disciplines are very intertwined disciplines and at the same time they are most often considered as two very distinct fields.

Following the SIGGRAPH curriculum, a workshop was held at Eurographics in September 2006 to develop an international curriculum for Computer Graphics studies. This curriculum has to be integrated in a computer science programs that respect the Bologna requirements of the European Union (see section 3.1) and reflects the international nature of the computer graphics education workshops to date. This initiative is further reported in (Bourdin,2006).

While the Siggraph knowledge base is more accurate and detailed in terms of the definition of concepts, the Eurographics workshop described the curriculum in more operational terms. In that perspective it distinguished two periods: a three year basic studies and a two year advanced studies that correspond roughly to the first and second pre-research cycles. The workshop stressed the importance of supporting the recommendation that at least one course in computer graphics should be included in every Bachelors computer science programme, and for making that course a requirement for graduation. It further advocates that such course called *beginner course* should serve as important source of learning and experience in communication from a computer to the user and suggest to be entitled "visual communication". It indicates that this *Visual communication course* should be taken in the second year of study, and could be followed with more specific but still basic introductory courses in the third year of the first period (Bachelor period). The list of basic courses includes graphics techniques beyond the beginning course (Modelling, Rendering, Animation), applications (Visualization, Interaction), and graphics systems (GPU Programming). Advanced courses are further examined and the suggestion of the workshop results in a detailed list including Rendering, Modelling, Animation, Visualization, Real-time Graphics.

Contrary to Siggraph knowledge base approach, Eurographics workshop conclusions concerning HCI and image processing is to consider both of them as very closely allied to Computer Graphics but not strictly within the field. They consider these topics should be included in the overall computer science curriculum and probably strongly encouraged or required for computer graphics students.

HCI CURRICULUM

The work on HCI Curricula was initiated earlier than the work concerning Computer Graphics field. The 1990 version of the curriculum is structured along several axes: definition of HCI and its relationship with other fields, individual courses designs, organizational and operational considerations on how courses ought to be articulated and what students should be involved, and finally, context dependant curricula design. In addition to these axes, the work provides a large amount of resources through appendices: recommended books, journals, videos and other relevant materials. In the context of this paper we mainly focused on : (1) knowlegde representations that can be extracted from this work and (2) course descriptions.

DOMAIN DESCRIPTIONS AND COURSES DESCRIPTIONS

Both the nature and content of available curricula differ significantly: the Computer Graphics curriculum is synthetic and mostly limited to concept and course description. Eurographics curriculum further introduced course descriptions and more organizational considerations and the HCI curriculum contains not only domain description and course description but it also contains discussions and considerations on the nature the field. Despite their differences, these curricula can all be very useful thanks to their ability to structure and stress the key concepts of computer graphics and HCI. In particular, domain and course descriptions can help understand and structure one or several courses.

In terms of domain description, these curricula also differ even though several overlaps can be found. Figure 2 illustrates some of the differences and overlaps between concepts from one curriculum to the other. A more careful analysis can help determining a core set of fundamental concepts coherent over curricula. These concepts can be further used to index most programs analyzed.

HCI Curriculum	Computer Graphics Curriculum	Eurographics Curriculum
• Geometry in 2- and 3- space, linear transformations […] • Solid modeling, splines, surface modeling, hidden surface removal, animation, rendering algorithms, lighting models • Color representation […]	**Fundamentals** • Representations of Visual Systems – pixels and polygons; 2D and 3D display, color […] **Math** […] • Transformations […] **Modeling** • 3D modeling […]	**Modeling I** Geometry and topology fundamentals; constructive solid geometry (CSG)[…] **Visualization I** Perception and visual communication; color ramps and other synthetic color schemes; […]

Figure 2: examples of concept differences and overlap between the 3 knowledge description perspectives

In order to get a better understanding of how a given course (or a given set of courses) covers the key concepts of the domain, we built tools to automatically generate colored tree overviews for displaying domain descriptions and related courses. Figure 3, 4 and 5 are example of such overviews. They were built from the four course descriptions available in the HCI Curriculum. Each course description contains a plan and relates to the domain description. The domain description can be considered as a tree representing categories of concepts depicted by discs (see Figure 3, for example). In this regard our approach is similar to the approach of Andrews et al. with Information slices. The four key parts of the domain description are affected different color hues: red for the "Nature of HCI" (N); yellow for " Use and Context of Computers" (U); green for "Human Characteristics" (H), blue for Computer System and Interface Architecture and purple for "Development Process" (D).

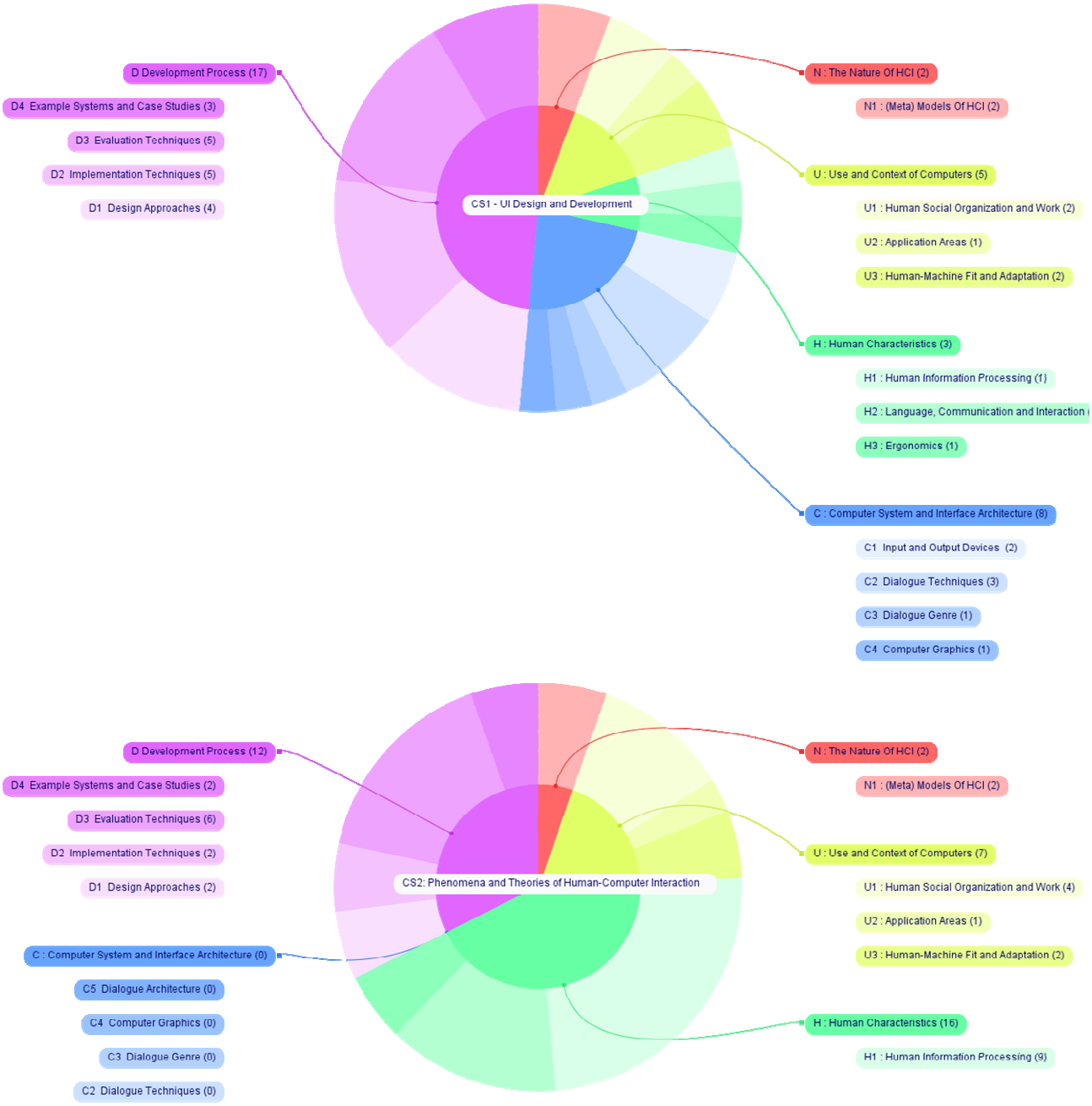

Figure 3: two first typical courses of the HCI curriculum with contrasted coverage of domain concepts

Since each course description includes the amount of time spent for each part of the key concepts of the domain description, we could use this information to best display how each course covers the different key concepts. The portion of disc related to each concept is computed to represent the relative amount of time devoted to the given concept by the underlying course (or set of courses). It shows in Figure 3 (top), for example, that the first course on "UI Design and development" is highly focused on concepts of the category D. Half the total amount of time of the course is devoted to concepts of this category. However all other concepts of the domain are also covered.

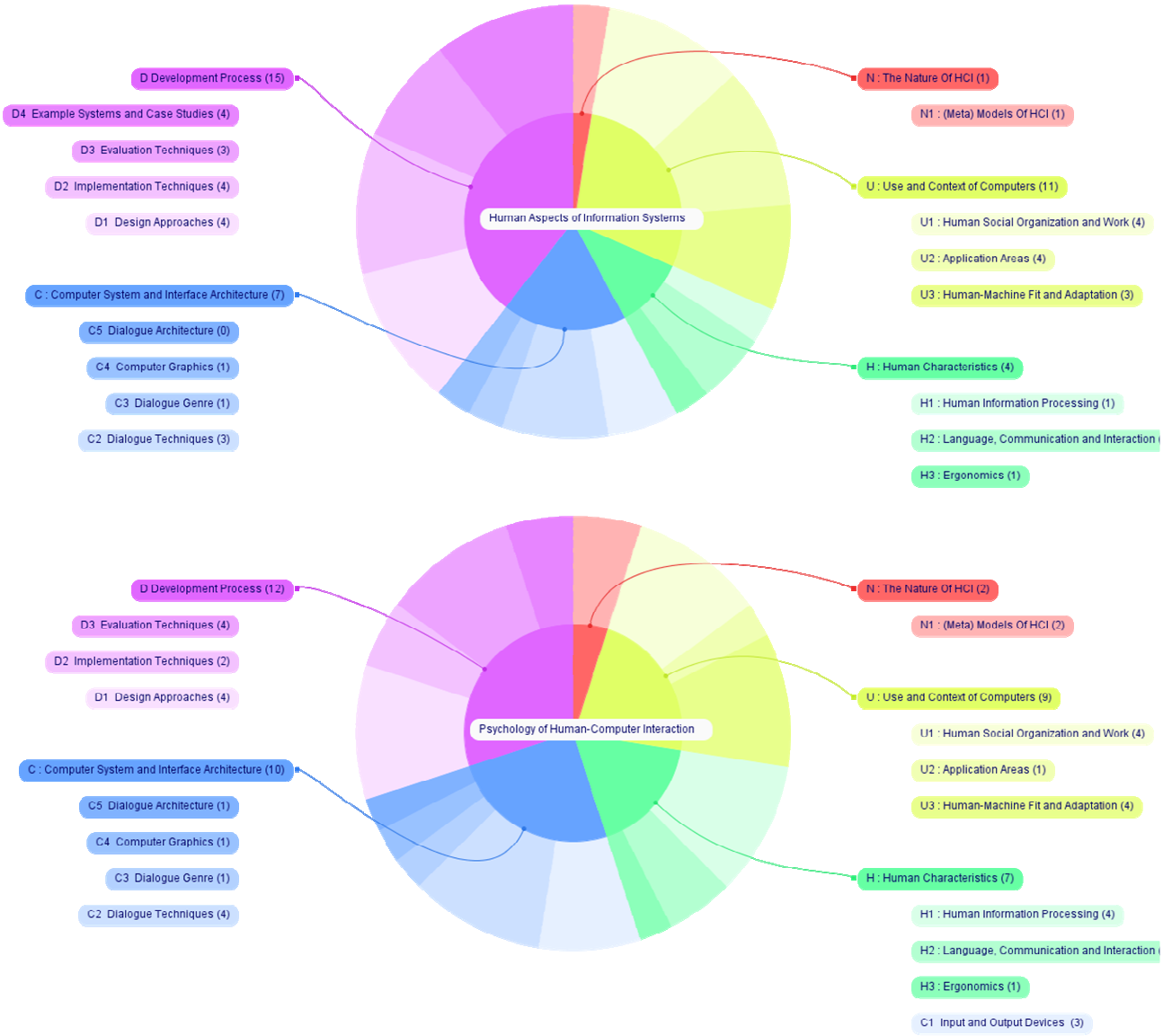

Figure 4: two typical courses of the HCI curriculum with well-balanced coverage of domain concepts

In the second course description (see Figure 3 - bottom), on the contrary, "Human Characteristics" are the main focus at the expense of other key concepts such as those under the category "Computer systems and Interface Architecture" which are not covered at all. Further courses (psychology of human-computer interaction and human aspects of information systems) are relatively well balanced over the key concepts of the domain which they cover relatively equally (see Figure 4). A similar approach was used to generate the Figure 5 that represents the coverage of a set of courses. For the example, the four course descriptions of the curriculum were used and the figure shows that altogether the courses represent a well balanced coverage of the domain concepts. This approach can be generalized to any set of courses, like the various courses of a given program or different related courses from different programs. These views in association with accurate data can help rapidly detect strength and focus of given programs.

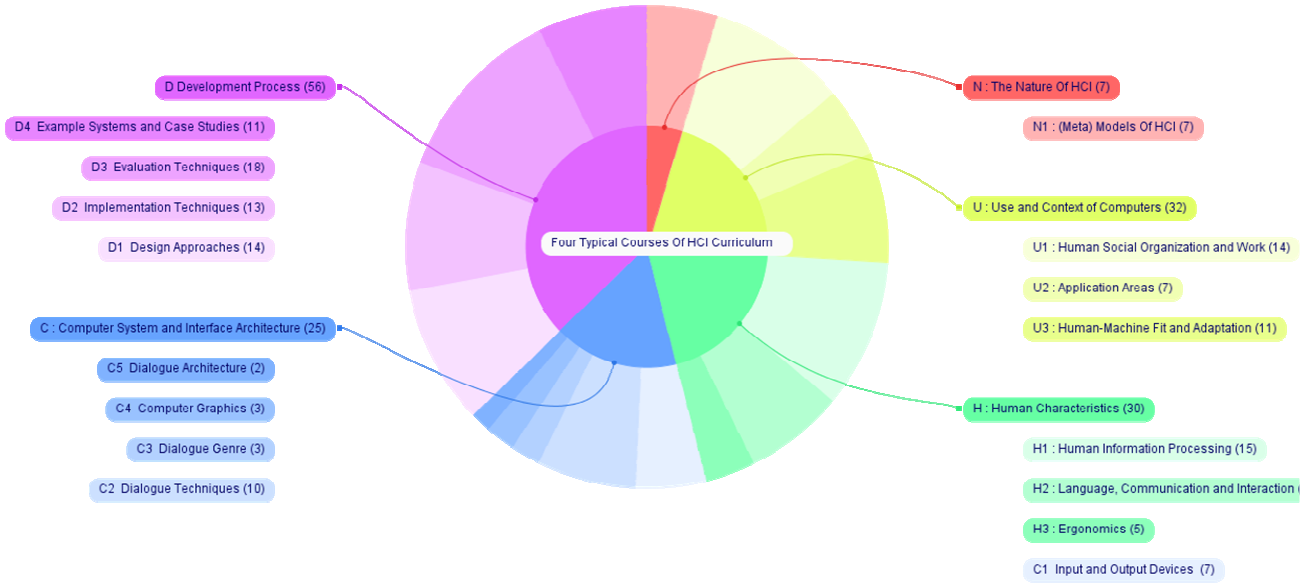

Figure 5: two first typical courses of the hci curriculum with contrasted coverage of domain concepts

4. THE SITUATION IN EUROPE: A CASE STUDY

To better help us understand and compare Computer Graphics and HCI education, we examine, as a first step in our study, sample Computer Graphics and HCI master programs taken from several universities in Europe. This idea joins the initiative of the HciBib, a well-know web site containing key ressources for HCI (Perlman). Our web portal (Hascoët, M & Rodriguez, N) wants to integrate programs information as well as curricula description to create a structured inventory.

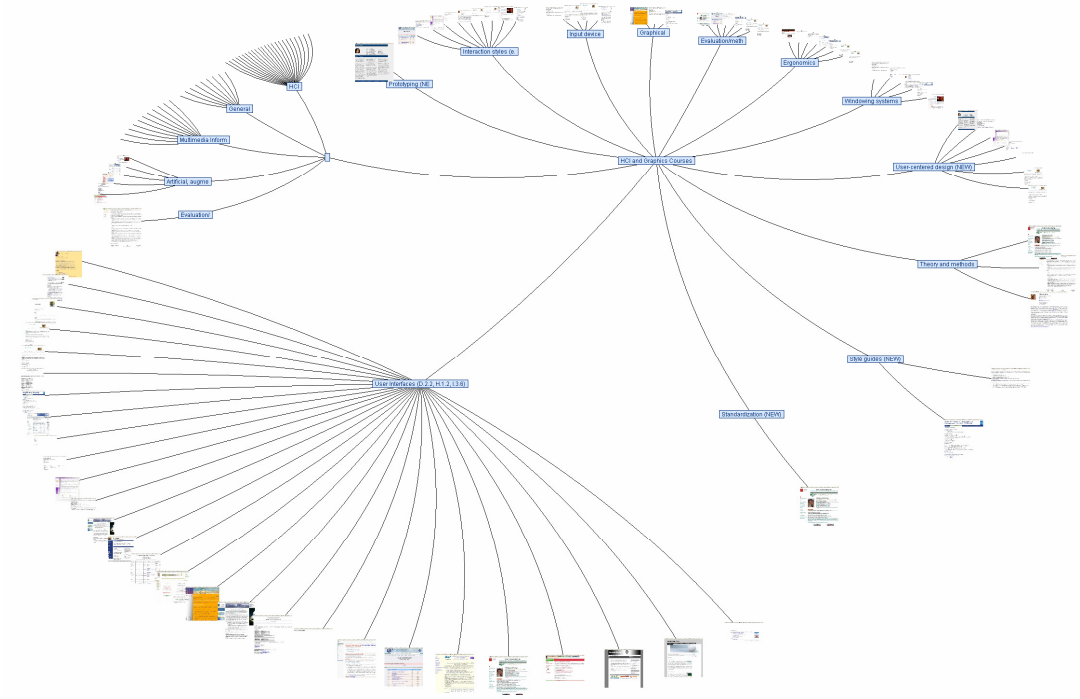

Figure 6: hyperbolic overview of available courses structure by domain concept description

Our aim is to classify Master programs information with respect to the reference curricula. This will allow us to highlight their mutual similarities and differences and make meaningful comparisons across countries and programs. In the next months, we intend to complete the database with LatinAmerican programs and thus will be able to generate more comprehensive graphical overviews, allowing deeper analysis and comparison of differents programs . Technologies such as PHP and GoogleMaps (figure 5) are employed in the development of our portal to maximise its usability.

Other overviews were also generated from the data collected on our web portal. These overview are based on hyperbolic drawing of domain concept description and related courses or programs. An example of such an overview is depicted in Figure 6. These views are helpful to rapidly explore the collection of ressources, courses and programs.

Figure 7: Geographic distribution of HCI Masters

5. CONCLUSION

The aim of this paper is twofold: first, we compare and discuss two published HCI and Computer Graphics curriculum proposals. We further generate graphical overviews of different types to show how it can help in the comparison of world-wide real programs from the curricula perspectives. Second, we use the results of this analysis to index several real HCI and CG masters programs. At the first stage of our study, we present a preliminary case study covering up to 50 programs in several European countries. Even though our results are limited in terms of domain (computer graphics and HCI field) and countries, our approach is general enough to include other educational domains and other countries.

REFERENCES

ACM. ACM Computing Classification System. http://www.acm.org/class/ 2006

Andrews Keith and Helmut Heidegger; *Information Slices: Visualising and Exploring Large Hierarchies using Cascading, Semi-Circular Discs*; Late Breaking Hot Topic Paper, IEEE InfoVis'98, Research Triangle Park, North Carolina, Oct. 1998, pages 9-12.

Bertoline, G. (1998). "Visual Science: An Emerging Discipline". In *Journal for Geometry and Graphics*, Vol. 2, No. 2, pp 181-187

Bertoline, G. (2001). "Forum: The Emerging Computer Graphics Discipline", *ACM SIGGRAPH 2001 Educator's Program*, "Program and Buyer's Guide", p. 81.

Bourdin J.J., Cunningham S., Fairén M., Hansmann W., Report of the *CGE 06 Computer Graphics Education Workshop*, Vienna, Austria, September 9, 2006, http://education.siggraph.org/conferences/eurographics/2006/cge-06-report-pdf

Eurydice, Focus on the structure of Higher Education in Europe, National trends in the Bologna Process 2006/07

Google Maps API. http://www.google.com/apis/maps/

Hewett T. T., Baecker R., Card S., Carey T., Gasen J., Mantei M., Perlman G., Strong G., Verplank W. "ACM SIGCHI Curricula for Human-Computer Interaction", ACM SIGCHI - http://sigchi.org/cdg/

Hascoët, M. and Rodriguez, N., http://www.lirmm.fr/~mountaz/IHM/

Laxer, C., Orr, J., (2006). "A Knowledge Base for the Emerging Discipline of Computer Graphics ":Report of the SIGGRAPH Education Committee Curriculum Working Group, http://education.siggraph.org/conferences/eurographics/2006/CKBreport_CGE06.pdf,

London communiqué, "Towards the European Higher Education Area: responding to challenges in a globalised world", *Bologna Process Conference*, 18 May 2007, http://www.dfes.gov.uk/londonbologna/

Perlman G. HCI Bibliography: Human-Computer Interaction Resources. http://www.hcibib.org/

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