

STRATEGIC PLAN

(2015-2025)

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DEPARTMENT OF COMPUTER SCIENCE

UNIVERSITY OF MARYLAND

EXECUTIVE SUMMARY

The University of Maryland Computer Science Department (CSD) plans to be a top-10 CS department in the USA by 2025. Located just outside Washington DC in the heart of some of the world's biggest consumers of computational research, CSD focuses on all aspects of computing. With high *US News & World Report* rankings in artificial intelligence, programming languages, and computer systems, CSD's focus on computer science fundamentals is complemented by UMIACS, the world's first interdisciplinary computing research institute, which provides our students with exposure to applied and multidisciplinary computing. By leveraging these resources, CSD students have gone on to create billion dollar companies like Google, Isilon Systems and Oculus. This report is a 10-year strategic plan that addresses how CSD will leverage both the unparalleled challenges and opportunities that the next 10 years will bring to strengthen core and applied CS on campus, as well as strengthening other campus departments at the same time.

CSD's global reputation rests on the quality of the research generated by students, researchers, and faculty. Over the next 10 years, in addition to building upon our existing strengths, we propose to become one of the world leaders in two new fields: *data science*, where outstanding fundamental CS research in machine learning and data mining is complemented on campus by the applied and interdisciplinary work undertaken by UMIACS, *augmented/virtual reality* where our department has an asymmetric advantage over other departments due to our special relationship with Oculus, and can leverage this to build AR/VR systems that link vast heterogeneous networks of intelligent sensors, devices, and robots with the power for AR/VR displays. Outreach focused not only on government and industry, but K-12 school systems, minority institutions, the press, and other entities will also play a key role in disseminating CSD research. In close collaboration with UMIACS and departments in multiple colleges, we propose to strengthen our presence in both core areas of CS as well as these two areas.

Recruiting top graduate students is essential to the success of our program, and we will increase our recruitment efforts in several ways: significantly improved "visit days" for admitted graduate students, a revised course structures that enables students to engage in research from the day they arrive on campus, and the creation of a culture and spaces that enhances student and faculty cross-fertilization and collaboration. We propose to significantly improve the quality of our undergraduate programs by structuring them so as to allow undergrads to balance CSD work with work in fields that are richly served by CS and provide service courses for other fields. Continuous monitoring of courses, exciting multi-semester individual/group projects, opportunities to participate in research, the creation of new hacker/maker spaces, as well as increased recognition of world class teaching will form the basis for improving our undergraduate programs. Specific effort will be directed towards internship and placement opportunities for both undergraduate and graduate students.

A world class CS department requires that diversity become part of the DNA of CSD. We propose innovative new strategies to hire minorities and women with specific mentoring programs, scholarships and funding instruments, reward structures, physical lab and collaboration spaces, and interdisciplinary programs intended to broaden the appeal of CS for the promotion of diversity in our faculty, student, and staff bodies.

I. PREAMBLE

The 2015-2025 Computer Science Department Strategic Plan has one overarching goal: to make UMD CS one of the top-10 computer science departments in the USA by 2025, irrespective of whether we are measured by the quality and impact of our research contributions, by the quality of the graduate students we produce, or by the quality of the undergraduates we produce. Our Strategic Plan therefore has 5 major elements:

- *Research Excellence.* Given the reality of limited resources, what new research areas should the department expand in, and how will we generate force multipliers to expand the quality and impact of our research?
- *Graduate Education.* World-class graduate students are at the very heart of any research enterprise. This Strategic Plan proposes new strategies to significantly enhance recruiting of new graduate students, enhance mentorship and oversight of graduate students, enhance the productivity of graduate students during their stay at Maryland, and maintain a life-long commitment to the promotion of our graduates, wherever they may eventually end up.
- *Undergraduate Education.* UMD CS undergraduates have gone on to create multi-billion dollar corporations such as Google, Isilon and Oculus. The Strategic Plan proposes new strategies to significantly enhance the undergraduate experience at UMD by providing new facilities, spaces, and programs that enhances their creativity, confidence, and entrepreneurial spirit.
- *Diversity.* One cannot be a world class institution if significant sections of the population do not have the opportunity to contribute to our undergraduate, graduate, research, and faculty bodies. This Strategic Plan proposes new methods to achieve increased levels of participation by minority groups and women at all levels in the department.
- *Outreach.* In addition to the outreach implicit in diversity efforts, there is a critical need to reach out to other stakeholders in performing and promoting research. These include academia, industry, government, the press, and the public. While the first three sets of stakeholders are typically covered by existing programs, CSD needs to make stronger efforts to reach out to the press and the public.

Each of these five over-arching elements of our Strategic Plan are discussed in the following sections.

II. RESEARCH EXCELLENCE

Our strategic plan will focus on expanding in two areas of growing importance in computer science – *data science* and *augmented/virtual reality*—coupled with an effort to strengthen central areas of CS. We will leverage a number of important resources in these efforts. First, we will rely on support from alumni, including the transformative gifts from the founders of Oculus and the new Iribe center. Second, we will grow our connections to local government and business institutions, raising significant new funds. Third, in the past, significant additional support from the university has produced world class programs in both computational biology and cybersecurity. With similar strong support from the university for our proposed new initiatives, we will greatly strengthen not only CSD, but also UMIACS

and several other departments and colleges in the university, making UMD a shining example of how computing can help advance many diverse fields.

II.A DATA SCIENCE & BIG DATA

Data Science/big data has become a critical area in computer science. The amount of data available is immense and growing. This is having a revolutionary impact on many fields.

Within Computer Science, areas of AI such as speech recognition, computer vision, and natural language processing now focus on learning from large data sets, and are making immense practical strides as a result. Database researchers are studying how to efficiently handle exploding volumes of heterogeneous, high-throughput data of varying quality. Cybersecurity researchers are increasingly turning to log and traffic data to identify and better secure our networks. Analyses of both computer and social networks are looking at increasingly volumes of data to better understand how to improve network performance and/or understand human behavior. *Data science* is at the very heart of all such efforts.

Outside Computer Science, data science is now being embraced by a variety of disciplines. Economists use it to learn models of market movement, make predictions, and avoid economic crises. Biologists use big data to better understand human (and animal/plant) genomes and link them with physiological conditions. Medical professionals and epidemiologists are using big data to predict epidemics such as the flu. Engineers use big data to better conserve energy and other resources, and fine-tune manufacturing systems to minimize faulty products. Agricultural experts use big data to better understand the conditions under which crop yields are high. Climate scientists use data science to understand both weather and climate related events. Animal conservation experts are using big data to better understand animal behavior and reduce poaching. Art historians are using data science methods to understand the spread of artistic influence during different periods of time. National security experts are using big data every day to protect America from terrorists. Simply put, we expect virtually every discipline on the UMD campus and beyond to benefit from the advances UMD will make in data science over the next 10 years.

We plan to strengthen core areas of Big Data and Data Science, with multiple hires in machine learning and new hires in databases and other core areas of data science. At the same time (in partnership with UMIACS and other departments on campus) we plan to pursue the applications of data science in critical areas such as advertising, aerospace engineering, agriculture, biology, biomedical engineering, economics, geography, human health, journalism, marketing, national security, psychology, robotics, and more. These initiatives will be carried out by a combination of existing faculty and new hires, some of whom may be jointly appointed with other departments. New faculty candidates in core areas such as machine learning and databases will be expected to have an interest and/or record in working with relevant application areas. Overall, this will allow us to develop fundamental new algorithms for the creation and use of data science while applying these algorithms in areas where they will have the highest impact, strengthening ties between CS and other departments. Where appropriate, some of these hires may be joint hires with other departments at UMD.

II.B AUGMENTED/VIRTUAL REALITY

CS at the University of Maryland has strength in computer vision, graphics, and visualization and human computer interaction, which are key areas in building systems that model and interact with the world and that interact with humans.

The Strategic Plan strongly recommends building out a world-class research program in Augmented/Virtual Reality. Recent forays into this market, such as Google Glass, the Oculus Rift, and BMW's Mini, suggest a great deal of commercial interest in this area – yet, there is no university with a world-class program around this theme. Moreover, CSD has an asymmetric advantage in this area by virtue of our close ties to Oculus. It is in both Oculus and UMD's interests to build a world-class partnership in augmented/virtual reality, making us the world's leading player in Augmented/Virtual Reality, and paving the way for a new generation of UMD entrepreneurs who help grow this industry to the next level.

Developing a world class AR/VR program requires hiring faculty in several areas. Clearly, we will need faculty in the area of 3-d graphics and visualization. But additionally, we will need faculty in areas supporting AR/VR such as real-time systems, mobile computing, low-energy computing, together with the ability to perform the real-time computation and analytics on high throughput data in order to power the AR/VS displays. These innovations, for example, also lie at the core of the “internet of things” which seeks to put (almost) everything on our planet on the Internet. The Internet of Things includes, as a subset, efforts such as smart cities, connected cars, and more. Such massive networked environments will contain millions of devices and sensors in relatively unconstrained settings that interact with humans. Examples of this include self-driving cars, household robotics and virtual and augmented reality. We expect these systems to become prevalent in the next decade. Our initiative in AR/VR can serve as the vanguard of a broader initiative in this deeply important area. In addition, our hires in data science/big data can support such important initiatives that will generate huge amounts of data. As in the case of Section II.A, related faculty may have joint appointments in UMIACS as well, potentially, in other disciplines such as electrical engineering, biomedical engineering, visual arts, and communication technology. A bold initiative in AR/VR would also help strengthen these auxiliary units on campus.

II.C BUILDING CORE COMPUTER SCIENCE

Becoming a top-10 computer science department requires that the department have outstanding faculty in the core areas of computer science. All top-10 computer science departments have excellent groups in core areas such as include algorithms/theory, artificial intelligence, databases, graphics and visualization, programming languages, software and software engineering, and networking/systems. Additionally, both data science and augmented/virtual reality require significant strengths in the very core of computer science. Moreover, CSD has made a commitment in recent years to computational biology, cybersecurity, and quantum computing – areas in which we need to continue to grow.

Because of this, it is necessary to build world class research programs in data science and AR/VR, while simultaneously building on the strengths of the departments in core computer science.

There is a critical need to significantly enhance our stature in core computer science by retaining superstars on our faculty and attracting new ones to round out our existing strengths.

III. GRADUATE EDUCATION

Our graduate students are our most important resource and asset, as they are primarily responsible for our research output and serve as our ambassadors to industry and other universities, and thus directly influence our standing as a top CS department. We are fortunate to attract very strong students from all over the world, and we need to not only continue to do so but also consider ways to make our department even more attractive to potential students. Our Strategic Plan focuses on how we can significantly improve the graduate student experience at the University of Maryland through the following instruments: a one on one faculty mentoring process with a commitment to diversity, improved educational programs that allow graduate students to perform research from the first day of their graduate school career, and improved internship and placement options, together with continued support for entrepreneurship. Moreover, this will be complemented with an aggressive recruitment campaign that seeks to identify both seasoned candidates and “diamonds in the rough”.

Improved Recruiting Efforts. The Strategic Plan recommends stronger and more aggressive recruiting efforts through a number of mechanisms including: improving the visit day experience, keeping continuous contact with admitted students via both current graduate students and faculty mentors, and designing an ‘online’ visit day for students who cannot visit in person, especially foreign students.

Research from Day One. The Strategic Plan recommends restructuring CS course requirements so that graduate students can get started with research as early as the day they arrive on campus. Specifically, course requirements will have looser temporal constraints so that students don’t feel compelled to put off all research till they wrap up course requirements. The sooner students can generate tangible research results, the more likely it is that they will get high quality internships, external fellowships and jobs.

Students as Owners of Research Results. The Strategic Plan recommends that students should be encouraged to seek and define their own research problems, in addition to, or in place of, problems suggested by research advisors. This can be incentivized by the creation of a fund that students can apply to for defining and solving such research problems. The result will be a sense of confidence and leadership amongst the students. It will also encourage serious collaboration between students and, coupled with entrepreneurship programs on campus, potentially lead to a slew of start-ups and entrepreneurial ventures.

Highlighting Student Accomplishments. The Strategic Plan recommends highlighting student (and alumni) accomplishments through a variety of instruments including press releases, placement on the department web page or YouTube channel, and more, so that students derive the full benefits of their

hard work and insights, and so that other universities and researchers are aware of the outstanding work of our students.

Masters or Certificate Programs. The Strategic Plan recommends the creation of an MS program in selected areas of computer science. Examples could include data science and game design.

With these steps, we are confident that we will not only recruit outstanding graduate students, we will also produce world class graduate students.

IV. UNDERGRADUATE EDUCATION

UMD CS undergraduate students have gone on to create world-renowned companies such as Google, Isilon and Oculus. The Strategic Plan seeks to build on these successes in order to develop world class undergraduates capable of achieving success and fame not only in computing, but in translating their computational knowledge to be movers and shakers in other related interdisciplinary fields.

Shaping an Undergraduate Program that Appeals to a Broad Diversity of Backgrounds and Ability Levels. With computing becoming an ever-increasing and dominant driver of both the US and world economies, there is a critical need to significantly expand the trained computing workforce. We propose to reshape the CS curriculum so that multiple flavors of computer science degrees are recognized, catering to students with varying interests. Some students majoring in other disciplines may only require minimal programming knowledge (e.g. Python) and very basic familiarity with databases to perform data science in their disciplines. Other students might want to build new mobile apps targeted at certain vertical markets, while yet other students might want to build faster and better networks. These goals are diverse and require diverse skill sets. A reshaped curriculum will significantly increase the output of high quality CS undergraduates from UMD, potentially improving the IT industry in Maryland and the DC area. Instruments that can be used to reshape the curriculum include: (i) use of multiple introductory CS course sequences so that students with diverse skills can use different paths to get a degree, (ii) use of multiple entry points into the CS curriculum so that students of varying levels can enter the program at appropriate points, (iii) relaxing pre-requisites of certain courses, and (iv) significantly strengthening the honors program so that students with specialized skills can perform research even if they don't plan to graduate with CS honors.

Develop Structures and Processes to Help Students Succeed. CSD should help students succeed, both within the department, and outside the department. This requires providing the space, equipment, financing, and mentoring support needed to transform student dreams into reality and to allow students to build out a *computational portfolio* that maps their skills and achievements in much the same way as an artist has a portfolio. The Strategic Plan recommends the creation of hacker/maker spaces, conference spaces available to students to discuss their out-of-the-box ideas and potential start-up ventures, and the ability to connect with angel investors and venture capitalists. Community interest groups and clubs focused on specific topics (e.g. cyber-security, Internet of Things, game development, mobile app development) should be encouraged and supported. Many of these clubs are already

functional and need further support – others should be built from the ground up. We must maintain strong student advising support generally, to help them make the best choices from among the many (more) that will be available. A stronger role for faculty advising in student-led initiatives and ventures is also recommended so that students can early on shape a technical and/or business plan that is likely to succeed.

Develop Structures to Value Outside Experiences. CSD students today are interning at companies like Amazon, Google, Microsoft and Groupon, gaining valuable experience during their path toward a degree. Other students are working at companies or government organizations where they also gain valuable experience. The Strategic Plan recommends that course requirements be adjusted appropriately so that such experiences, with appropriate faculty oversight, are given due credit.

Help Students Better Connect to the External World. CSD students today need better connections to the external world. The Strategic Plan recommends the creation of new opportunities that allow students to connect more closely with faculty, alumni, speakers and visitors from industry, angel investors and venture capitalists, and more. This requires a program that will bring in speakers to CSD whose target audience is the undergraduate population, together with a mechanism that nurtures a longer term relationship between these visitors, the students involved, and UMD. While some efforts have already been made in this direction, we need to strengthen such efforts through increased support and resources.

Improve Faculty Instruction and Educational Modalities. Quality of instruction is at the very heart of all educational programs. The Strategic Plan recommends the following steps to improve the quality of education: (i) Continuous peer evaluation of teaching by instructors and faculty, (ii) A reward system that recognizes the value of pedagogical contributions made by CSD faculty, (iii) recruitment of a world class core of instructors to supplement the faculty, (iv) use of technology such as MOOCs in further improving the quality of education, and (v) use of technology such as interactive video to perform interactive hands on “how to” sessions that teach by doing. Across all of these efforts, we must continuously reassess what is working, and not, by gathering the right data and comparing process to outcome.

V. DIVERSITY

Fostering diversity within all our constituencies (faculty, staff, graduate, and undergraduate students) is critical to our long term success. Broadly defined in terms of gender, race, socioeconomic status, sexual orientation, religion, and political beliefs, diversity is a positive force that contributes to intellectual creativity, and helps create a rich learning environment for all our students. At the same time, our field is faced with a tremendous challenge - comparatively few women and other underrepresented minorities choose computer science as a major or as a career, even when compared to other STEM disciplines.

Create and foster an open, inclusive, and supportive environment for all members of our department. CSD must create an environment that is respectful, sensitive, and inclusive of diverse members of society. The Strategic Plan recommends establishing a departmental policy (consistent with official

University policies) emphasizing the expectations we have of all of the members of our department in terms of creating an open and inclusive environment. In addition, the Chair should periodically review CSD's performance with respect to diversity. Other instruments within the department to increase inclusiveness include coffee hours, informal lunches, game nights, and hikes to which all are invited.

Create a permanent diversity community. CSD should establish a permanent committee tasked with implementing the strategic goals outlined in this document, and provide a forum for discussing the activities and findings of the committee with the rest of the faculty (e.g., one or more diversity and outreach faculty meetings each semester). The committee should develop concrete plans of action and report, on a regular basis, on their implementation to the Chair and the rest of the faculty. Instances of specific actions could include organizing more departmental colloquia that reflect a diversity of speaker backgrounds.

Create a more diverse recruitment policy. The Strategic Plan recommends the creation of explicit instruments, such as committees, whose goal is to recruit outstanding undergraduate students, graduate students, researchers, and faculty, who better reflect the diversity of our nation. Instruments to support this could include: (i) the use of standard questions for all candidates during the interview process. (ii) The use of a broader set of qualifications beyond those currently defined - such as interest in interdisciplinary research, or involvement in educational and outreach activities.

Advance Recruitment of Diverse Faculty. Hiring senior and junior faculty from under-represented groups forms a cornerstone of our policy to achieve diversity. Hiring senior women or faculty from underrepresented minorities will play an important role in providing role models and mentorship for junior hires. The Strategic Plan recommends the creation of specific diversity-sensitive mentoring programs (involving mentors who may be Emeritus UMD faculty and/or external faculty) that better addresses the needs of faculty from under-represented areas. Moreover, such faculty should be insulated from unnecessary committee work so that they can excel in their chosen research field.

Develop a support structure for students with diverse backgrounds. The Strategic Plan recommends developing support opportunities that help students from a diverse background 'come up to speed' (if needed) so that they have a fair chance at succeeding in our demanding undergraduate and graduate programs.

Outreach to Schools and Minority Institutions. The Strategic Plan recommends developing stronger connections to local high schools and community colleges, especially those with a large fraction of students from underrepresented minorities. There are many programs to reach out to schools (K-12) in order to educate students about computing. There are programs where the students come to the University and others where undergraduate students go into the schools. The Strategic Plan recommends the following instruments to increase diversity: (i) mentoring high school students in research or other projects, (ii) having a larger presence in events such as science fairs and other afterschool organizations, as well as a larger presence in the CSTA-Maryland (Computer Science Teachers Association), (iii) increasing and supporting participation in the Grace Hopper Conference and Tapia Conference and other similar meetings and venues that allow students from underrepresented

groups to feel less isolated, meet possible role models, and learn how to deal with issues that arise from feelings of being an outsider.

Some of these goals are already being addressed through groups like “Women in Computing” which now makes a strong effort to support female undergraduate students, graduate students, and faculty. CSD should be encouraged to increase support for the activities of the “Women in Computing” group.

VI. OUTREACH

Outreach is a critical part of all aspects of research and teaching in the department. However, outreach also presents an unprecedented opportunity to highlight the research being done at CSD, garnering fame for our faculty and students, and presenting new avenues for recruiting students and faculty, while securing additional research funding. As a consequence, significantly improved outreach forms a cornerstone of CSD’s strategic plan.

Outreach to Industry. With computer science becoming an integral part of virtually every business, there is now an unprecedented opportunity to increase outreach, not just to the traditional IT industry, but also to industry verticals. These include opportunities to link with industries we have traditionally not been closely connected to including pharma, financial services, oil and mining, amongst others. The Strategic Plan recommends the use of several instruments to help forge such bridges including: (i) participation by CS faculty in industry forums linked to their interests and (ii) the holding of “open houses” at UMD focused on industry verticals.

Outreach to Government. CSD should better leverage its location in the Washington DC metropolitan area to significantly strengthen connections with the US government. Specific instruments to help shore up these connections include: (i) regularly supporting faculty requests to serve on government committees, (ii) recommending faculty members to testify as needed on Capitol Hill, (iii) and seconding faculty to both funding institutions such as DARPA and policy making bodies such as Congressional staff. Holding regular open houses featuring CSD research presents another opportunity for building stronger links with government.

Outreach to the Press. In addition to traditional academic publications, there may be no better way to secure fame for our faculty and students than good press coverage of CSD research. The Strategic plan recommends the following steps: (i) CSD needs to maintain a database of members of the press with an interest in technology issues. (ii) CSD needs to partner with journals such as Science, Nature, CACM and IEEE Computer to ensure that the message gets out when CSD faculty and students publish outstanding research results that have general appeal to the public. (iii) CSD needs to more aggressively highlight faculty research through social media channels such as YouTube, Twitter, and Facebook.

Outreach to High Schools and Community Colleges. Outreach to high schools and community colleges presents an unprecedented opportunity to help populations in Maryland who have traditionally not been helped in a substantive way by CSD. By reaching out to community colleges and high schools, CSD has the opportunity to serve the State of Maryland by increasing the pool of highly talented graduates, as well as CSD’s goal of recruiting outstanding students.

VII. CONCLUSION

The UMD Computer Science Department seeks to become a top-10 CS department by 2025. In order to achieve this, five major steps need to be taken.

- *Significantly Enhance the CS Research Program.* In order to grow into a world-class department, CSD needs both outstanding faculty in core computer science, as well as world class faculty in a few selected additional disciplines. We propose to become a world-class program over the next 10 years in two new areas: data science and in augmented/virtual reality.
- *Significantly Enhance the CS Graduate Curriculum.* Graduate students are at the very core of making CSD a great research department. We plan to significantly improve the quality and quantity of graduate students we recruit through a variety of devices: significantly improved “visit days” for admitted graduate students, a revised course structures that enable students to engage in research from the day they arrive on campus, and the creation of a culture and spaces that enhances student and faculty cross-fertilization and collaboration.
- *Significantly Enhance the Undergraduate Program.* We propose to significantly improve the quality of our undergraduate programs by structuring them so as to allow undergrads to balance CSD work with work in fields that are richly served by CS and provide service courses for other fields. Continuous monitoring of courses, exciting multi-semester individual/group projects, opportunities to participate in research, the creation of new hacker/maker spaces, as well as increased recognition of world class teaching will form the basis for improving our undergraduate programs. Specific effort will be directed towards internship and placement opportunities for both undergraduate and graduate students.
- *Significantly Enhancing Diversity.* CSD cannot be a great department if representation by significant demographic groups (e.g. women and minorities) is not actively encouraged, nurtured, and enhanced. We propose to develop a suite of outreach efforts (e.g. in underserved schools and community colleges, school science fairs), as well as programs targeted at recruiting and enhancing the experience of women and minorities once they arrive at UMD. In addition, we will significantly increase support for groups such as the existing Women in Computing group which has similar goals.
- *Significantly Enhancing Outreach.* Great institutions have great partnerships. CSD plans to build a world-class set of partnerships with four diverse sets of stakeholders: other academic and research organizations, companies, government agencies and labs, and the press. We plan to expand these links by holding research “open houses” to which other university, company, and government personnel are invited, by nominating faculty to liaise when appropriate with Congress, and by improving visibility for research at UMD through appropriate press releases that highlight faculty and student accomplishments. In addition, we will make specific efforts to reach out to community colleges and high schools in Maryland.

We are confident that with the strong support of the university administration, the college, UMIACS, and the faculty, staff, and students in CSD, we will be a top-10 computer science department by 2025.