

PROPOSAL

MASTER OF SCIENCE IN DATA SCIENCE

Questions about the program should be directed to:

Dr. Mitsunori Ogihara, Professor
Department of Computer Science
#305-284-2308
ogihara@cs.miami.edu

Dr. Athena Hadjixenofontos, Director of Engagement
Center for Computational Science
#305-243-4529
ahadjixenofontos@med.miami.edu

Executive Summary

The Master of Science in Data Science is an interdisciplinary graduate program that combines the teaching of domain-specific and technical skills for analyzing large data sets. Built upon a core of foundational data science courses in Computer Science and Mathematics, and a selection of courses from data science application domains, the program is interdisciplinary in nature. Students interested in data science tools will be able to focus on tool principles and tool development, and students interest in data science applications will be able to focus on the application of data science tools with a selection of courses that develops skills in one of three application areas. The program also provides its students the option of doing an industrial internship, to acquire professional experience. The program allows the various academic units involved to add courses in their specific application domains, thus keeping the program updated and relevant to current practice and industrial needs. The program is both academic and professional in nature, providing courses that are true to a Master's level degree, and courses that reflect the needs of the profession.

The objectives of the program are as follows:

- To teach students programming skills not only for understanding the computer programs they use but also for getting started in developing their own programs
- To teach students mathematical and statistical foundations sufficient for understanding the underlying algorithms and the models developed
- To teach students how to turn domain questions into scientific investigations and how to interpret the results in their respective domain
- To teach practical problem-solving skills through an internship

The curriculum consists of three components: data science tool courses, data science application courses, and an internship. Students must complete at least 30 credits of graduate level courses to complete the degree. Credit can be given for prior study. At least 15 credits of courses must be completed at the University of Miami. Each student's selection of courses must be approved by a member of the administrative group (to avoid course overlap, ensure coherence, etc.). Several tracks have been defined to provide focused study within the general requirements of the degree. Students may choose to follow a track, or may build their own individualized program in consultation with their advisor.

Students in this program are likely to come from a range of backgrounds, however, they must meet specified minimum quantitative GRE requirements. We aim to attract students with interests in data mining, artificial intelligence, visualization, smart cities, media, geographic information systems (GIS), and climate modeling.

The program will be administered by the Center for Computational Science, jointly with the academic units that offer the courses (Computer Science - College of Arts and Sciences, Electrical and Computer Engineering - College of Engineering, Mathematics – College of Arts and Science, School of Architecture, Meteorology and Physical Oceanography - RSMAS, Journalism and Media Management - School of Communication). The Department of Computer Science will serve as the home department for the degree. A body of industrial board members will provide professional advice regarding the program content, and will assist in internship placement.

The University of Miami Library system holdings and online resources are adequate to support this program. As the courses that comprise the program are already in existence, the various departments have adequate facilities, equipment, and space for the teaching. The Center for Computational Sciences will provide additional computing resources to the departments. The program uses existing courses, and courses that the various academic units are already committed to creating, so that there is no budget required for course

creation.

Revenue distribution: 30% of tuition revenue from all Master's degree programs returns to the Academy net of any waivers or scholarships. After that the CCS will take 15% to cover the costs of administering the program including the salary of a Program Coordinator to be housed at the CCS. After that all income will be distributed to the colleges and schools whose academic units teach the program's courses, according to the number of credit hours taught per student. Each college and school will distribute income to the academic units according to their individual college and school policies.

Approval from the Curriculum Committee of the College of Arts & Sciences

Monday, March 12, 2018 at 9:05:39 AM Eastern Daylight Time

Subject: Fwd: Master of Science in Data Science Proposal
Date: Monday, March 12, 2018 at 8:33:42 AM Eastern Daylight Time
From: Mallery, Charles H.
To: Tobin, Maryann
Attachments: y.MSDS-final-09mar18.pdf

Sorry,

forgot to include you on the final CCC approved version.

Thanks, Charles Mallery

associate dean, college of arts & sciences
Merrick bldg., room 304 - (305) - 284-3188 - cmallery@miami.edu

Begin forwarded message:

From: "Charles H. Mallery" <cmallery@miami.edu>
Subject: Master of Science in Data Science Proposal
Date: March 12, 2018 at 8:31:41 AM EDT
To: Rose-Ketlie Glemaud <rglemaud@miami.edu>
Cc: Geoffrey Sutcliffe <g.sutcliffe@miami.edu>

Rose,

At its regularly scheduled meeting on 09 March 2018 the College's Curriculum Committee reviewed and approved the proposal for MS in Data Science.

Attached please find a pdf file with the proposal and all its supporting documentation for consideration by the College Council and faculty of the College.

Thanks, Charles Mallery

associate dean, college of arts & sciences
Merrick bldg., room 304 - (305) - 284-3188 - cmallery@miami.edu

Letter of Support from the Director of the Center for Computational Science

UNIVERSITY OF MIAMI
**CENTER for
COMPUTATIONAL
SCIENCE**



Nicholas Tsinoremas, PhD

Founding Director
Professor of Medicine
Professor of Computer Science
Professor of Health Informatics
ntsinoremas@miami.edu

Gables One Tower, Suite 600 T 305.243.4962
1320 S Dixie Highway (Locator Code 2965) F 305.243.9732
Coral Gables, FL 33146-2926 ccs.miami.edu

December 11, 2017

Dean Leonidas Bachas
Ashe Administration Building
1252 Memorial Dr, Room 227
Coral Gables, Florida 33146-2509

Dear Dean Bachas,

This letter confirms the support of the Center for Computational Science for the Master of Science in Data Science proposed to be housed under the Department of Computer Science in conjunction with the Center for Computational Science and other units of the university. The Center for Computational Science is happy to administer the program and offer the use of computing resources as needed.

Regards,

Nick Tsinoremas, Ph.D.
Center Director

Letter of Support from the Chairperson of the Department of Computer Science

UNIVERSITY
OF MIAMI



Department of Computer Science

POSTAL ADDRESS

P.O. Box 248154
Coral Gables
Florida 33124
USA

TELEPHONE

+1 305 2842158
+1 305 2842268

FACSIMILE

+1 305 2842264

EMAIL

geoff@cs.miami.edu

November 1, 2017

To: Whom it May Concern
From: Geoff Sutcliffe
Subject: Master of Science in Data Science

This letter confirms the support of the Department of Computer Science for the Master of Science in Data Science, proposed by the Department of Computer Science in conjunction with the Center for Computational Sciences and other units of the university. The Department of Computer Science is pleased to have courses in the program.

Regards,

Geoff Sutcliffe
Professor and Chair of Computer Science

Letter of Support from the Department of Mathematics

UNIVERSITY OF MIAMI
COLLEGE of
ARTS & SCIENCES



Department of Mathematics
P.O. Box 249085
Coral Gables, FL 33124-4250

Phone: 305-284-2575
Fax: 305-284-2848
math@math.miami.edu

To: Leonidas G. Bachas, Dean
College of Arts & Sciences

Nick Tsinoremas, Director
Center for Computational Science

From: Robert Stephen Cantrell, Chair
Department of Mathematics

Date: February 13, 2018

Subject: Letter of Support for the Master of Science in Data Science

I am writing to express the support of my Departmental colleagues and myself for the Master of Science in Data Science proposed jointly by the Department of Computer Science at the College of Arts & Sciences and the Center for Computational Science.

Our department has agreed to provide courses for this interdisciplinary program, as outlined in the proposal. We are pleased to participate in this new degree.

Regards,

A handwritten signature in blue ink, appearing to read 'RSC', written over the printed name.

Robert Stephen Cantrell, Ph.D.
Professor and Chair
Department of Mathematics

Letter of Support from the School of Architecture

UNIVERSITY OF MIAMI
SCHOOL of
ARCHITECTURE



P.O. Box 249178
Coral Gables, FL 33124

Phone: 305-284-3731
Fax: 305-284-2999
www.arc.miami.edu

December 11, 2017

Re: Letter of Support
Master of Science in Data Science

To: Geoff Sutcliffe, Nick Tsinoremas

This letter confirms the support of the School of Architecture for the Master of Science in Data Science proposed to be housed in the Department of Computer Science in conjunction with the Center for Computational Science, the School of Communication, the Rosenstiel School of Marine and Atmospheric Science and other units of the university. The interdisciplinary design of the Master in Data Science program is extremely valuable for students who seek to combine rigorous technical training with data science applications in architecture. The School of Architecture has been an integral collaborator in the process of creating the Master in Data Science program, and is pleased to have a track in Smart Cities as part of the program.

Regards,

Rodolphe el-Khoury, PhD
Dean and Professor

Letter of Support from the Miami Business School (Marketing Department)

UNIVERSITY OF MIAMI
**SCHOOL of BUSINESS
ADMINISTRATION**



Department of Marketing
P.O. Box 248147
Coral Gables, FL 33124-6554

Phone: 305-284-5935
Fax: 305-284-5326

November 8, 2017

To: Geoff Sutcliffe, Nick Tsinoremas

This letter confirms the support of the Marketing Department for the Master of Science in Data Science proposed to be housed under the Department of Computer Science in conjunction with the Center for Computational Sciences and other units of the university. The marketing department is pleased to teach courses related to empirical marketing research methods in the program.

Regards,

Michael Tsiros
Patrick J. Cesarano Professor of Marketing and Department Chair
Marketing Department
School of Business Administration
University of Miami.

Letter of Support from Rosenstiel School of Marine and Atmospheric Science

UNIVERSITY OF MIAMI
ROSENSTIEL
SCHOOL of MARINE &
ATMOSPHERIC SCIENCE



Department of Atmospheric Sciences
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149, USA

Phone: 305-421-4046 Email: bkirtman@rsmas.miami.edu

2 November 2017

To: Geoff Sutcliffe, Nick Tsinoremas

This letter confirms the support of the Department of Atmospheric Science/Rosenstiel School of Marine and Atmospheric Science for the Master of Science in Data Science proposed to be housed under the Department of Computer Science in conjunction with the Center for Computational Sciences and other units of the university. The Department of Atmospheric Science/Rosenstiel School of Marine and Atmospheric Science is pleased to have courses in the program.

If you need any further information, please do not hesitate to contact me either by phone (305-421-4046), fax (305-421-4696) or by e-mail (bkirtman@rsmas.miami.edu).

Sincerely,

Ben Kirtman
Professor, Department of Atmospheric Sciences
Director, Cooperative Institute for Marine and Atmospheric Studies
Rosenstiel School of Marine and Atmospheric Sciences
Program Director, Climate and Environmental Hazards
Center for Computational Science
University of Miami

Letter of Support from the Big Data Advisory Board



THINERGISTICS
Strategic Technology Solutions

Letter of Support for the Professional Master in Data Science program

I, as a member of the University of Miami Center for Computational Science Big Data Advisory Board, are writing to express full support for the Professional Master in Data Science Program proposed as a collaboration between the College of Arts and Sciences, the School of Communication, the School of Architecture, the Rosenstiel School of Marine and Atmospheric Science, the College of Engineering, and the Center for Computational Science at the University of Miami.

As a key member of a wide range of industries in the South Florida region, I have first-hand experience of the needs that this program seeks to fill.

Every industry, without exception, can benefit from leveraging available data in driving decisions in areas such as the optimization of operations, marketing, human resource management, and many others. Technological developments have made possible the handling of data at larger and larger scales in both volume and complexity. These computational resources create the potential for any organization to dive into data to extract useful, actionable insights. However, for this potential to be realized, industries need an expert workforce, one that is both trained in the computational tools and with a deep understanding of the unique features that represent each domain.

Multiple universities have begun to respond to the changing landscape by creating graduate programs in Data Science. However, these programs often lean heavily towards either the technical or the domain skills, and have yet to successfully integrate the two. We believe that establishing the Master of Data Science program at UM as a collaboration between multiple Schools and Colleges will successfully address this challenge of integration and produce individuals who are highly skilled in both the technical computational competencies *and* in each of their domains. In doing so, the proposed program has the potential to establish the University of Miami as a leader in data science not only in South Florida, but nationwide.

As a CCS Big Data Advisory board member, I am eager to support the Professional Master in Data Science program in the following ways: (a) by providing insight to the Program Directors with respect to the skills that would increase the employability of the program graduates, and in doing so shaping the curriculum, and (b) by providing paid 6-month internship opportunities for students in the proposed program at my organization, including co-mentoring of the student by a member of the organization in addition to the student's academic advisor.

We eagerly anticipate collaborating with the program Steering Committee and the Program Directors on establishing the Master of Data Science program at UM.

Sincerely,

Hector Irizarry

Partner & Co-Founder

Additional Letter of Support from the Big Data Advisory Board



Royal Caribbean International
1050 Caribbean Way
Miami, Florida 33132

tel: 305.539.6000
www.royalcaribbean.com

Letter of Support for the Professional Master in Data Science program

I, as a member of the University of Miami Center for Computational Science Big Data Advisory Board, are writing to express full support for the Professional Master in Data Science Program proposed as a collaboration between the College of Arts and Sciences, the School of Communication, the School of Architecture, the Rosenstiel School of Marine and Atmospheric Science, the College of Engineering, and the Center for Computational Science at the University of Miami.

As a key member of a wide range of industries in the South Florida region, I have first-hand experience of the needs that this program seeks to fill.

Every industry, without exception, can benefit from leveraging available data in driving decisions in areas such as the optimization of operations, marketing, human resource management, and many others. Technological developments have made possible the handling of data at larger and larger scales in both volume and complexity. These computational resources create the potential for any organization to dive into data to extract useful, actionable insights. However, for this potential to be realized, industries need an expert workforce, one that is both trained in the computational tools and with a deep understanding of the unique features that represent each domain.

Multiple universities have begun to respond to the changing landscape by creating graduate programs in Data Science. However, these programs often lean heavily towards either the technical or the domain skills, and have yet to successfully integrate the two. We believe that establishing the Master of Data Science program at UM as a collaboration between multiple Schools and Colleges will successfully address this challenge of integration and produce individuals who are highly skilled in both the technical computational competencies *and* in each of their domains. In doing so, the proposed program has the potential to establish the University of Miami as a leader in data science not only in South Florida, but nationwide.

As a CCS Big Data Advisory board member, I am eager to support the Professional Master in Data Science program in the following ways: (a) by providing insight to the Program Directors with respect to the skills that would increase the employability of the program graduates, and in doing so shaping the curriculum, and (b) by providing paid 6-month internship opportunities for students in the proposed program at my organization, including co-mentoring of the student by a member of the organization in addition to the student's academic advisor.

We eagerly anticipate collaborating with the program Steering Committee and the Program Directors on establishing the Master of Data Science program at UM.

Sincerely,

A handwritten signature in black ink, appearing to read "Gang Wang".

Gang Wang, Ph.D.
Director, Operations Data & Analytics
Royal Caribbean International
(305) 982-2195 | gwang@rccl.com

Additional Letter of Support from the Big Data Advisory Board



March 7, 2018

Letter of Support for the Professional Master in Data Science program

I, as a member of the University of Miami Center for Computational Science Big Data Advisory Board, are writing to express full support for the Professional Master in Data Science Program proposed as a collaboration between the College of Arts and Sciences, the School of Communication, the School of Architecture, the Rosenstiel School of Marine and Atmospheric Science, the College of Engineering, and the Center for Computational Science at the University of Miami.

As a key member of a wide range of industries in the South Florida region, I have first-hand experience of the needs that this program seeks to fill.

Every industry, without exception, can benefit from leveraging available data in driving decisions in areas such as the optimization of operations, marketing, human resource management, and many others. Technological developments have made possible the handling of data at larger and larger scales in both volume and complexity. These computational resources create the potential for any organization to dive into data to extract useful, actionable insights. However, for this potential to be realized, industries need an expert workforce, one that is both trained in the computational tools and with a deep understanding of the unique features that represent each domain.

Multiple universities have begun to respond to the changing landscape by creating graduate programs in Data Science. However, these programs often lean heavily towards either the technical or the domain skills, and have yet to successfully integrate the two. We believe that establishing the Master of Data Science program at UM as a collaboration between multiple Schools and Colleges will successfully address this challenge of integration and produce individuals who are highly skilled in both the technical computational competencies *and* in each of their domains. In doing so, the proposed program has the potential to establish the University of Miami as a leader in data science not only in South Florida, but nationwide.

As a CCS Big Data Advisory board member, I am eager to support the Professional Master in Data Science program in the following ways: (a) by providing insight to the Program Directors with respect to the skills that would increase the employability of the program graduates, and in doing so shaping the curriculum, and (b) by providing paid 6-month internship opportunities for students in the proposed program at my organization, including co-mentoring of the student by a member of the organization in addition to the student's academic advisor.

We eagerly anticipate collaborating with the program Steering Committee and the Program Directors on establishing the Master of Data Science program at UM.

Sincerely,

A handwritten signature in black ink, appearing to read "Pete Martinez", with a long horizontal flourish extending to the right.

Pete Martinez

CEO

Game Changer Tec LLC.

PROPOSAL

MASTER OF SCIENCE IN DATA SCIENCE

Name of the program for the Diploma:

Master of Science in Data Science

Name of the program on student transcripts:

Master of Science in Data Science

[and if they follow a track] with a Track in *Track Name*

Responsible administrative unit for the program:

Department of Computer Science, College of Arts and Sciences

Proposed date for implementation:

Fall 2019

1. Rationale

a. Exact Degree Title.

The College of Arts & Sciences' Department of Computer Science seeks to offer an interdisciplinary master's degree in cooperation with the School of Architecture, Department of Computer Science, Department of Mathematics, School of Communication, and the Rosenstiel School of Marine and Atmospheric Science. The program will be administered by the Center for Computational Science (CCS). The degree will be titled the Master of Science (MS) in Data Science.

b. Purpose and Goals of the Degree.

Data Science is a broad term referring to scientific investigations through analysis of datasets that are large in size, heterogeneous in nature, in multiple formats, coming from disparate data sources. Analysis of data sets can find new correlations, revealing emerging business trends and opportunities, and leading to new scientific discoveries. Professionals in many parts of society, including scientists, business executives, practitioners of media and advertising, and government analysts, regularly have difficulties with large data sets in areas such as internet search, finance, healthcare, and business. The ability to analyze large and complex data sets accurately for modeling and prediction leads to more confident decision-making, and better decisions can mean greater operational efficiency, cost reduction, and reduced risk.

Many large companies today have data science departments. Data scientists who can not only perform various data analysis techniques but also are able to interpret the results by drawing on their domain knowledge into actionable items are in high demand, as executives seek talented individuals capable of unlocking the hidden value in big data to garner strategic insights and business results. The challenges of modern data science require data scientists to possess strong training in both data analysis technologies and also domain specific issues. Founded on computer science, mathematics, statistics, and optimization techniques, data scientists add deep content knowledge in specialized applications such as communications, architecture, and marine sciences. Training data scientists requires an interdisciplinary approach that ensures that the students are well-trained and able to take up the role of data scientist in any organization. The Harvard Business Review

has dubbed data science as “the sexiest job of the 21st century.”

Data science consists of many steps. It starts with project conception then moves on to collection and harvesting data from possible data sources, preprocessing the collected and harvested data, integrating multiple data sets for analysis, conducting analysis for modeling and prediction, visualizing obtained results for interpretation, developing actionable plans from obtained results, and preserving the curated data. Because of the size and complexity of the data sets, traditional data processing tools (for example, those available in spreadsheet programs and statistical software) are inadequate. In practice, many of the steps in analyzing large data sets are done using purpose-specific computer programs that require more than a click of a button; they require a solid understanding of the principles that the computer programs embody.

c. Motivation and Demand

The position of Data Scientist is a growing job market. The need for data science and the shortage of data scientists are well articulated in various reports [Herold; Orihuele and Bass; Sents], including an in-depth analysis [McKinsey]. Those who suspect that data science is a “hype” warn that the demands for data scientists may lessen soon, when many of the by-hand tasks of the data analytics processes are incorporated into software tools [Darrow]. A counter argument is that while software tools become more intelligent, the size and complexity of the datasets keep increasing. The 2016 McKinsey Report states, “Back in 2011, the McKinsey Global Institute published a report highlighting the transformational potential of big data.¹ Five years later, we remain convinced that this potential has not been overhyped. In fact, we now believe that our 2011 analyses gave only a partial view. The range of applications and opportunities has grown even larger today.” The report estimates that there will be a shortfall of 250K data scientists, but 50% of the work could be automated. As of April, 2017, there are 35K job openings listed at Glassdoor.com and 11K job openings listed at LinkedIn.com. The median salary of data scientists is estimated to be around \$118K while that of skilled programmers is estimated to be \$65K, according to Wired.com. Thus, the market potential of data science degree programs appears to be high.

At least two dozen universities now have a Master of Science in Data Science (or a similar degree). The current offerors include: Arizona State (Business Analytics), Carnegie Mellon (Computational Data Science), Central Florida, Columbia, Cornell (MPS in Applied Statistics), Georgia Tech., Illinois at Urbana Champaign (Professional MS), Illinois Tech, Indiana, Johns Hopkins (online), Minnesota, NYU, North Carolina State (Analytics), Northwestern (Analytics), Rochester, Rutgers (MS Business and Science), San Francisco, Southern California, Stanford, Texas A&M (Analytics), UC Berkeley (online), UC San Diego (Analytics), Virginia, Washington – Seattle, and Wisconsin. The duration of these programs ranges from 10 to 12 months with specific guidelines from selected programs highlighted in Section 6 of this proposal.

Interdisciplinary master’s degree programs with an emphasis on professional training already exist at the University of Miami. For example, the College of Arts & Sciences currently offers interdisciplinary professional master’s degree programs in International Administration, Liberal Arts, Latin American Studies, and Mathematical Finance, as well as departmental professional master’s degrees in Applied Behavior Analysis, Anthropology, Criminology and Criminal Justice, International Studies, and Public Administration. Additionally, the Professional Science Master’s (PSM) program at RSMAS prepares its students for science careers in industry, government, and nonprofit organizations, where employment demands are growing. The curricula are structured to allow students to complete their degree in as little as 12 months, with the training and internship experiences necessary to prepare them for careers in today’s professional job market.

There are two existing UM master’s degree programs whose contents have some overlap with the proposed program: Master of Science in Business Analytics in the School of Business and Master of Fine Arts in

Interactive Media in the School of Communication. The MS in Data Science is distinctly different from these other programs at the University of Miami, with a focus on teaching key skills for conducting *science* with data and a strong emphasis on *interdisciplinary* education. It will draw from a separate pool of potential students, and produce graduates with a different set of data science skills. As such, the students will emerge into different job markets, outside of communication, finance, and business.

2. Curriculum

a. List the major divisions of the discipline in which graduate degree work will be offered.

The program will be administered by the Center for Computational Science, jointly with the academic units that offer the courses: School of Architecture, Department of Computer Science, Department of Mathematics, School of Communication, and RSMAS). Since computation serves as the backbone of data science and since the Center has served and collaborated with the university-wide research community, the CCS is an ideal organization for taking the lead role in administering the program, and will appoint a program coordinator to take overall responsibility for the program. The program coordinator will be responsible for recruiting, finance, internships, and program administration. The Department of Computer Science (College of Arts & Sciences) will serve as the home department for the degree. Additionally, the program will be advised by the following:

- *Administrative Group*: This group will represent all the academic units teaching courses in the program, and will be in charge of overseeing the validity and health of the program. No changes can be made to the academic structure without approval of this group. These members will be in charge of advising their respective students. The current members are:
 - Prof. Alberto Cairo (Journalism and Media Management, School of Communications)
 - Prof. Ben Kirtman (Meteorology and Physical Oceanography, RSMAS)
 - Prof. Mitsunori Ogihara (Department of Computer Science, College of Arts and Sciences)
 - Prof. Rodolphe el-Khoury (School of Architecture)
 - Prof. Mei-Ling Shyu (Department of Electrical and Computer Engineering, College of Engineering)
- *Industrial Advisory Board*: The advisory board will consist of representatives from companies who are willing to take in and supervise interns from the program for six months. Presently the board members include:
 - Pete Martinez, Chairman and CEO, GameChangerTec
 - Hector Irizarry, Founding Partner, Thinergistics
 - Gang Wang, Manager, Operations & Analytics, Royal Caribbean Cruise Lines
 - Matthew Pape, Director, Market Data Analytics & Insight, Ryder - Global Marketing
 - Louis Gidel, Chief Medical Informatics and Quality Officer, Baptist Health South Florida
 - Daniel Cohen, Senior Vice President, Digital Payments and Labs for MasterCard Latin America and the Caribbean

b. Provide a detailed description of the proposed program.

The objectives of the program are as follows:

- To teach students programming skills not only for understanding the computer programs they use but also for getting started in developing their own programs
- To teach students mathematical and statistical foundations sufficient for understanding the underlying algorithms and the models developed
- To teach students how to turn domain questions into scientific investigations and how to interpret the results in their respective domain
- To teach practical problem-solving skills through an internship

3. Requirements

a. Prerequisites.

Admission to the program will be handled by the Center for Computational Science. Requirements are:

- i. Completion of an application
- ii. A Baccalaureate degree from an accredited institution
- iii. A cumulative undergraduate GPA of 3.0
- iv. Introduction to Probability and Statistics and Computer Programming I (or equivalents). Students may be admitted with deficiencies, which must be completed in addition to the degree requirements.
- v. GRE general test scores
 - a. Applicants must rank in the 65% percentile or higher in the Quantitative Reasoning test. There is no minimum score requirement for the other parts of the GRE.
- vi. Students from non-English speaking countries must send either TOEFL or IELTS scores.
 - a. TOEFL minimum score: Internet based - 92; Computer based - 237; Paper based - 580.
 - b. IELTS minimum score: 6.5.
- vii. A personal statement of intent in which the applicant details reasons for pursuing the degree.

Credit can be given for prior study. At least 15 credits of courses must be completed at the University of Miami.

b. Courses.

The curriculum consists of three components: data science tool courses, data science application courses, and an internship. Students must complete at least 30 credits of graduate level courses to complete the degree. Each student's selection of courses must be approved by a member of the administrative group (to avoid course overlap, ensure coherence, etc.).

Data Science Tools (at least 12 credits)

The core data science tool courses are discipline independent courses that teach the fundamental skills of data science.

- Technical Prerequisites
 - CSC6XX Computing and Mathematics for Data Science
(This will provide prerequisite knowledge for students from a non-technical background. Not available to students who have the material from prior studies.)
- Core (9 credits)
 - Statistics
 - MTH642 Statistical Analysis
 - Machine Learning or Data Mining
 - ECE648 Machine Learning
 - or ECE677 Data Mining

- o Data Visualization
 - CSC688 Data Science and Visualization
 - or JMM622 Infographics and Data Visualization
- Computer Science
 - o Programming (at least 3 credits):
 - CSC6XX Programming in Python (to be developed by CSC faculty)
 - CSC632 Introduction to Parallel Computing
 - CSC640 Algorithm Design and Analysis
 - o Database Systems:
 - CSC623 Theory of Relational Databases
 - xor ECE672 Object-Oriented and Distributed Database Management Systems
 - ECE697 Advanced Big Data Analysis
 - o Data Visualization:
 - CSC688 Data Science and Visualization
 - JMM622 Introduction to Infographics
 - o Machine Learning and Data Mining:
 - CSC6XX Principles and Practice of Deep Learning (to be developed by new faculty)
 - CSC746 Neural Networks and Deep Learning
 - ECE648 Machine Learning
 - ECE653 Neural Networks
 - ECE677 Data Mining
 - ECE753 Pattern Recognition and Neural Networks
 - MKTXXX Text Mining
- Mathematics and Statistics
 - IEN713 Applied Regression Analysis
 - MTH624 Introduction to Probability Theory
 - MTH625 Introduction to Mathematical Statistics

Data Science Applications (at least 6 credits)

These are courses specific to application domains. Each academic unit offers courses relevant to their discipline, and students who are focused on applications will be advised to take a selection of courses that develops skills in one application area. Note that the courses listed here are only an initially available list, and the various application areas are expected to add more.

- ARC594 GIS in Urban Design
- ARC684 RAD LAB-UM
- ARC685 BIM/Virtual Design and Construction
- CSC645 Introduction to Artificial Intelligence
- xor ECE637 Principles of Artificial Intelligence
- GEG680 Spatial Data Analysis I
- JMM692 Interactive Data Visualization for the Web
- Courses for the graduate programs in Atmospheric Science (ATM), Ocean Sciences (OCE) and Meteorology & Physical Oceanography (MPO)

Data Science Internship (at most 6 credits)

This is a recommended three- or six-month internship. Three month internships are for 3 credits, and are done in either semester or the summer. Six month internships are for 6 credits, and are done either from spring to summer or from summer to fall. The academic unit responsible for the student coordinates the internship with the program coordinator in the Center for Computational Science. The student is assigned an internship supervisor in the academic unit and also at the location of the internship. The internship culminates with a

report detailing the work done and knowledge gained, and a presentation to faculty and students in the program. Appropriate courses codes will be created.

Tracks

Several tracks have been defined to provide focused study within the general requirements of the degree. Students may choose to follow a track, or may build their own individualized program in consultation with their advisor.

- Technical Data Science (Department of Computer Science)

Core: (9 credits)

MTH642 Statistical Analysis

ECE648 Machine Learning

xor ECE677 Data Mining

CSC688 Data Science and Visualization

Tools: (12 credits)

(A) Programming:

CSC6XX Programming in Python

xor CSC632 Introduction to Parallel Computing

xor CSC640 Algorithm Design and Analysis

(B) Machine Learning:

CSC6XX Principles and Practice of Deep Learning

or CSC746 Neural Networks and Deep Learning

or ECE648 Machine Learning

(C) Data Analysis:

ECE697 Advanced Big Data Analysis

xor ECE677 Data Mining

(D) Statistics:

MTH624 Introduction to Probability Theory

xor MTH625 Introduction to Mathematical Statistics

Applications (6 credits)

Internship (3 credits)

- Smart Cities (School of Architecture)

Core: The Data Science Core and Tools courses may be selected in consultation with an advisor.

Data Science Applications courses: Students in the Smart Cities track need to take the following courses in their application domain:

ARC594 GIS in Urban Design

ARC684 RAD LAB-UM

ARC685 BIM/Virtual Design and Construction

Internship (3 or 6 credits)

- Data Visualization (School of Communication)

Core: The Data Science Core and Tools courses may be selected in consultation with an advisor.

Data Science Applications courses: Students in the Data Visualization track need to take the following courses in their application domain:

CSC688 Data Science and Visualization
JMM622 Introduction to Infographics
JMM692 Interactive Data Visualization for the Web

Students interested in spatial visualization may take any of the following electives:

GEG691 Geographic Information Systems I
GEG693 Geographic Information Systems II
GEG680 Spatial Data Analysis I
GEG681 Spatial Data Analysis II

Internship (3 or 6 credits)

- Marine and Atmospheric Science (RSMAS)

Core: The Data Science Core and Tools courses may be selected in consultation with an advisor.

Data Science Applications courses: Students in the Marine and Atmospheric Science track may design a program of study suited to their career goals and interests from the list of application domain electives comprised of the course lists for the graduate programs in Atmospheric Science (ATM), Ocean Sciences (OCE) and Meteorology & Physical Oceanography (MPO).

Internship (3 or 6 credits)

c. Examinations

Each course contributes independently to completion of the program, and there is no cumulative examination. Students must finish with a GPA of 3.0 in order to be awarded the degree.

4. Students

Students in this program are likely to come from a range of backgrounds, however, they must meet the minimum quantitative GRE requirements outline above. We aim to attract students with interests in data mining, artificial intelligence, visualization, smart cities, media, geographic information systems (GIS), and climate modeling.

5. Resources

a. Assessment of Library Holdings

The University of Miami Library system holdings and online resources are adequate to support this program.

b. Physical Resources: Existing Facilities, Equipment, and Space

As the courses that comprise the program are already in existence, the various departments have adequate facilities, equipment, and space for the teaching. The Center for Computational Sciences will provide additional computing resources to the departments.

c. Budget

The program uses existing courses, and courses that the various academic units are already committed to creating, so that there is no budget required for course creation.

Revenue distribution: 30% of tuition revenue from all Master's degree programs returns to the Academy net of any waivers or scholarships. After that the CCS will take 15% to cover the costs of administering the program including the salary of a Program Coordinator to be housed at the CCS. After that all income will be distributed to the colleges and schools whose academic units teach the program's courses, according to the number of credit hours taught per student. Each college and school will distribute income to the academic units according to their individual college and school policies.

6. Comparisons

Top Ranked MS in Data Science Programs

- [MS in Data Science, Columbia University](#), Offered by the Data Science Institute at Columbia
 - 30 credits, 6 core courses covering the essentials of computer science, probability, statistics and machine learning and a capstone project in the last semester.
 - Remaining 3 courses can be taken as electives from across the university, including computer science, statistics, business, and civil engineering
 - Research and internship opportunities available.
- [MS in Data Science, New York University](#), Offered by the Center for Data Science at NYU
 - 36 credits, 6 core courses covering the essentials of statistics and machine learning and a capstone project in the last semester.
 - Remaining 6 courses can be taken as electives in applied statistics, bioinformatics, computer science, mathematical finance, political science and engineering
 - Research and internship opportunities available.
- [MS in Data Science, Johns Hopkins](#), Offered by the Whiting School of Engineering
 - Also offers a Post-Graduate Certificate in Data Science
 - 30 credits, online and blended, capstone project
 - Research and internship opportunities available.
- [MS in Computational Data Science, Carnegie Mellon University](#), Offered by the School of Computer Science
 - 36 credits, 2 concentrations – Analytics or Systems.
 - 5 core courses, 3, electives, 2 seminar courses and 1 capstone project is required
 - Electives which can be taken from the Department of Computer Science.
 - Research and internship opportunities available.

Local/State Programs

- [MS in Data Science, Florida International University](#), Offered by the School of Computing and Information Science
 - 30 credits, 4 specializations – Computational Data Analytics, Business Analytics, Hospitality Analytics, Biostatistics Data Analytics
 - 4 core courses, electives, capstone project
 - No research component
- [MS in Data Analytics, University of Central Florida](#), Offered jointly by the College of Sciences and the College of Engineering and Computer Science
 - 30 credits, 8 core courses, 2 electives, capstone project
 - Paid internships available
 - No research component

Other Related Degree Programs

- [MS in Analytics, Northwestern University](#), Offered jointly by McCormick School of Engineering, Kellogg School of Management, and Medill School of Journalism
 - 15-month program, fixed curriculum
 - Both practicum and capstone projects are industry sponsored.
 - No research component
- [MS in Information and Data Science, UC Berkeley](#), Offered by the School of Information
 - Fully-online with a short residency requirement (“immersion experience)
 - 20-month fixed curriculum, capstone project
 - No research or internship component
- [MS in Statistics: Data Science, Stanford](#), Offered jointly by the Department of Statistics and the Institute for Computational and Mathematical Engineering
 - Track within the MS in Statistics degree
 - 45 credits/units, no thesis but a capstone project
 - Lab work in the Stanford Data Lab
 - Internship and research opportunities are available

7. References

- [Darrow] Barb Darrow (2015) Data science is still white hot, but nothing lasts forever. *Fortune Technology*, May 21, 2015. <http://fortune.com/2015/05/21/data-science-white-hot/>
- [Herold] Benjamin Herold (2016) In Analytics Economy, Demand for Data Scientists Outpaces Supply, McKinsey Says. *Education Weekly*, December 8, 2016. http://blogs.edweek.org/edweek/DigitalEducation/2016/12/analytics_economy_data_science_mckinsey.html
- [McKinsey] *The Age of Analytics*. McKinsey Global Institute. December, 2016.
- [Orihuela and Bass] Rodrigo Orihuela and Dina Bass (2015) Help Wanted: Black Belts in Data. *Bloomberg*, June 4, 2015. <https://www.bloomberg.com/news/articles/2015-06-04/help-wanted-black-belts-in-data>
- [Sents] Rob Sents (2016) Want to Become a Data Scientist? Where the Jobs Are And What Employers Are Looking For. *Forbes Magazine*, November 16, 2016. <https://www.forbes.com/sites/emsi/2016/11/16/want-to-become-a-data-scientist-where-the-jobs-are-and-what-employers-are-looking-for/#7c82a9915760>