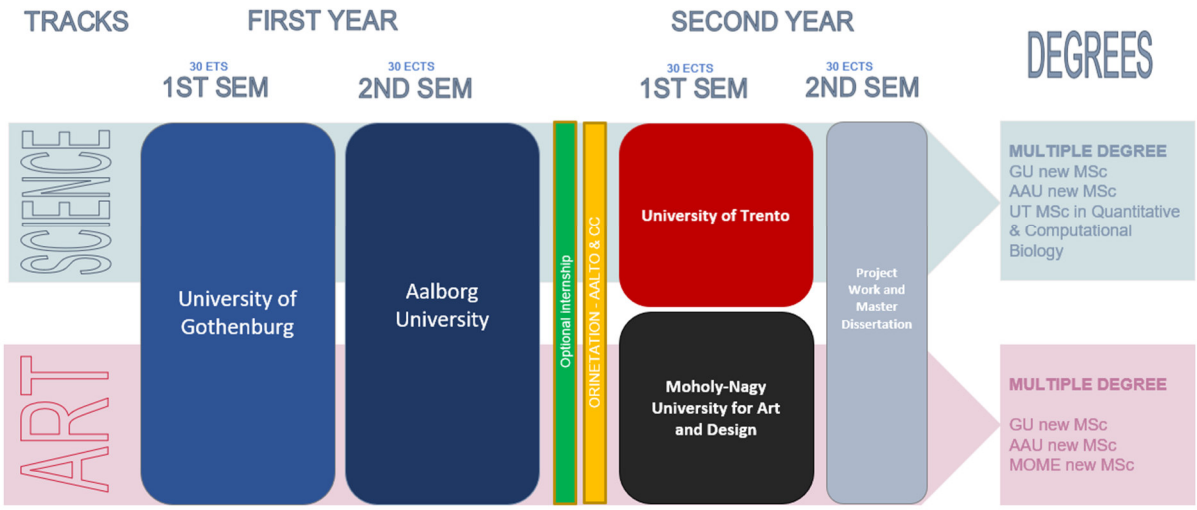
ABRAx

Complex and Adaptive Systems Across Robotics, Biology, Art and Design

Erasmus+ Erasmus Mundus Design Measures

Joint Study Plan

The proposed study plan is based on the students' compulsory mobility in the first three semesters (in the sequence: Gothenburg, Aalborg, Trento, or Budapest). In the fourth semester, students can also move to any of the Partners involved in the ABRAx Programme.



MSc Science Track

First Year, 1st Semester - University of Gothenburg

First Year, 2nd Semester - Aalborg University

Optional Internship: July/August

Orientation school Aalto: 1st week of September

Second Year, 1st Semester - University of Trento

Second Year, 2nd Semester - Flexible location

Graduation session: September/October

MSc Art Track

First Year, 1st Semester - University of Gothenburg

First Year, 2nd Semester - Aalborg University

Optional Internship: July/August

Orientation school Aalto: 1st week of September

Second Year, 1st Semester - Moholy-Nagy University of Art and Design

Second Year, 2nd Semester - Flexible location

Graduation session: September/October

ABRAx GU semester, outline

Program plan for 1st semester in Gothenburg. 2 tracks science and arts, i.e. 2 groups of students, one with BSc or similar, including (30+ credits) maths and programming (and arts interest), one with BA/BFA (with some maths and programming experience or interest).

Year 1 Semester 1 – Track 1 (Science) University of Gothenburg		**30 ECTS**
Semester	***Courses***	***ECTS***
1	Introduction to complex systems in art and science	15
1	Artificial neural network (INF)	7.5
1	Simulation of Complex Systems (MAT)	7.5

Year 1 Semester 1 – Track 2 (Art) University of Gothenburg		**30 ECTS**
Semester	***Courses***	***ECTS***
1	Introduction to complex systems in art and science	15
1	Elective course 1 (see below)	7.5
1	Elective course 2 (see below)	7.5

Course Descriptions

The focus for the first semester is to establish the topic and provide introductory skills and establish a shared discourse within the master program, spanning both tracks. Track 1 and Track 2 will share an

introductory course that spans the whole semester, focused on establishing a shared set of skills between the tracks, ending with interdisciplinary group projects. In parallel, students from each track will take track-specific two courses, introducing relevant topics.

Both tracks

Introduction to Complex Systems in Art and Science (15 ECTS) new

This is a new course that is shared between both tracks, with the purpose of introducing the topic of the program and providing a shared set of theoretical and practical skills around the topic, bridging the participating disciplines. The course is designed to give a broad introduction to the topic of using complex systems in art and science, its history, aesthetics, and artistic and research practices. The course starts with an introduction to the history and theory of art-science collaborations, including examples from both music and the visual and performing arts, followed by an overview of contemporary practices. In lectures and seminars, the students are exposed to a large number of examples of works from professional practitioners, including guest lectures from artists, scientists, and engineers active in the field, representing the state-of-the-art. Relevant theories are introduced, such as the aesthetics of complex systems, basic cybernetics, artificial life, and the application of systems thinking in the arts. In the second half of the course, the students form interdisciplinary groups and create an art-science project together, based on the theories taught in the first half of the course, and a shared theme. The projects can take the form of installations, interactive artworks, performance works, music, or other aesthetic expressions. The resulting works will be presented publicly at the end of the semester, and each student is expected to submit an essay containing contextualised reflections around the group project and the produced artwork, their particular contribution to it, and their individual learning process.

Science track

Artificial neural networks (7.5 ECTS) link

This course describes how neural networks are used in machine learning. Neural networks are distributed computational models inspired by the structure of the human brain, consisting of many simple processing elements that are connected in a network. Neural networks have revolutionised how we solve important problems in the engineering sciences, such as image analysis (object recognition and location), prediction, and control. The course gives an overview and a basic understanding of currently used neural-network algorithms, and exhibits similarities as well as differences between these methods. The main emphasis of this introductory course is on three connected topics: recurrent (Hopfield) networks,

supervised learning with deep neural networks, and unsupervised learning (reinforcement learning). The goal is to explain how and why the algorithms work, when and how they fail, how to program the standard methods from scratch, and how to use packages that allow to easily set up and to efficiently run larger networks.

Simulation of complex systems (7.5 ECTS) link

The course introduces the students to simulation techniques frequently used in complex systems, emphasising agent-based modelling and networks. We discuss examples of applications in physics, biology and social science. The aim of the course is to 1) give the students the level of understanding needed to decide on simulation methodology for a specific problem, 2) define and implement a moderate-size simulation project, and 3) evaluate the results from their simulations.

Arts track

Elective course 1 (7.5 ECTS)

Elective course 2 (7.5 ECTS)

Available topics, besides artistic practices, include Philosophy of art, Aesthetics, Art in society, Music in Society, Improvisation workshop, and a variety of master seminar courses. The options from these courses include the available relevant courses given at master level at the HDK-Valand Academy of Art and Design and the Academy of Music and Drama, depending on the students' artistic background and interest. Together, these two schools provide training within fine and applied arts, design, music, theatre, opera, sound art, and many other art forms.

Year 1 Semester 2 – Track 1 (Science) Aalborg University		**30 ECTS**
Semester	*Courses*	*ECTS*
2	Introduction to Data Science	10
2	Computational Thinking – Creative Computing for All	10
2	Embodied Interaction	5
2	Humans in the Loop (Robotics, AI and Ethics)	5

Year 1 Semester 2 – Track 2 (Art) Aalborg University		30 ECTS
Semester	*Courses*	*ECTS*
2	Introduction to Data Science	10
2	Computational Thinking – Creative Computing for All	10
2	Embodied Interaction	5
2	Humans in the Loop (Robotics, AI and Ethics)	5

Course Descriptions

Track 1 and Track 2 will follow the same courses during the second semester at AAU. These courses have been approved for MSc degrees and will be taught by a combination of faculty from the SSH and TECH faculties. Focus on ethics, robotics, and machine learning/data science.

An effort will be made to have students enrolled in Track 1 and Track 2 work on joint projects and group assignments together, wherever possible.

Introduction to Data Science (10 ECTS) link

This module provides students with a basic introduction to data science with the aim of approaching design problems from a data-driven perspective. Students will be introduced to concepts and principles behind relevant data science methods, such as testing research hypotheses, machine learning, analysing social and textual data, and information access (search, recommendation & personalization). Students are expected to apply this knowledge to data-driven design problems. Through the module, the student must gain knowledge and understanding of: relevant data-driven methods for testing research hypotheses; understanding of basic principles behind supervised and unsupervised machine learning; principles behind methods & techniques to derive insights for large amounts of textual data; understanding of the basic concepts & principles behind analysing network data; and principles behind methods & algorithms for information access, such as search, recommendation & personalization. Students will acquire skills in identifying and using data science methods and techniques with the purpose of informing data-driven design decisions. Moreover, they must through the module acquire competences to critically reflect on which data science methods and techniques are most relevant to solve design problems in a data-driven manner and independently take responsibility for their own learning, development and specialisation within data-driven design.

Computational Thinking – Creative Computing for All (10 ECTS) link

Computational thinking is about creating, solving problems, designing systems and understanding human behaviour, by drawing on fundamental computer science concepts, practices and perspectives. It is about deconstructing complex problems and producing solutions that can be processed by both humans and computers. In this course, we use block programming as a hands-on approach to learn about key concepts and practices from computational thinking. The course is an opportunity for students to upgrade their basic computer literacy and prepare for a future where we all need to be able to transform our ideas into digital form and evaluate and assess digital creations impact on our academic field. After this course, students will be able to express their own ideas through block programming; be able to reflect critically on usage of computational solutions and communicate about computational products in interdisciplinary contexts. *No prior programming experience is needed to attend this course.* Through the module, the student will gain knowledge and understanding of: theories and methods relevant to computational thinking; scientific issues related to computational thinking; ethical aspects of computational thinking; main terms related to computational thinking. They will also be able to critically reflect on computing in everyday spaces and analyse/understand/reflect on the impact of computational solutions in a real-world context.

Embodied Interaction (5 ECTS) link

The course presents the emerging theory of embodied interaction interleaved with practical implementations of intelligent systems, where the participants work on open-source, community-supported interactive audio-visual coding platforms, such as Processing and open Frameworks. The focus of the theoretical part is on embodied mind and cognition, intelligent agents, and movement as design material. These will be centred on emerging literature. Students will obtain the following qualifications: knowledge about standard methods and techniques in embodied interaction; the ability to understand and describe movement as a design material; understand the bodily skills needed for technological development, decision making, steering and path finding; understand what movement qualities are and how they are extracted from movement tracking data; and apply methods and techniques to real world scenarios (e.g., games, robots, public installations, etc.).

Humans in the Loop (5 ECTS) link

This course introduces students to key developments and current challenges in robotics and AI, and highlights how the humanities and social sciences can inform research practices that result in ethical, inclusive and responsible robots and AI. Through research-based teaching and practice-based workshops, students will learn to identify and implement theories and methods from the arts, humanities,

and social sciences to address relevant challenges in the fields of robotics, human-robot interaction (HRI), human-computer interaction (HCI), AI and machine learning. Key issues that will be addressed are interaction, embodiment, systems theory, ethics, and societal impact. During this course, students will learn and apply practical quantitative and qualitative methods to bridge humanities research with relevant topics in engineering and computer science in their own mini-projects. Students will gain knowledge and understanding of: theories and methods addressing concepts of interaction; embodiment; ethics and social impact in the field of robotics, HRI/HCI, and AI; research questions and challenges within robotics, HRI/HCI, and AI research; and approaches to bridge interdisciplinary perspectives on robotics, HRI/HCI, and AI research. Students will also acquire skills in scientific theories, methods, research, and design tools for understanding, developing and/or analysing research questions and solutions within robotics, HRI/HCI, and AI, and assessing and selecting among scientific theories, methods, and tools and to develop new analytical and solution models on robotics, HRI/HCI, and AI from a humanistic, social scientific or artistic perspective to critically evaluate technologies, tools, and practices from a human-centred perspective.

Optional Internship: July/August

Orientation school Aalto University: 1st week of September

Aalto University in collaboration with Cultivamos Cultura will host a week-long autumn school at the start of year 2 for all students in both tracks to help students explore options towards the final thesis/project.

Year 2 Semester 1 (Science) – Trento University		**30 ECTS**
Semester	***Courses***	***ECTS***
1	Molecular Basis of Cell Structure and Function (BIO)	6
1	Cellular and Molecular Dynamics (BIO)	6
1	Organic and Biological Chemistry (CHEM)	6
1	Experimental Biochemistry (CHEM)	6
1	Laboratory of Biological Data Mining (INF)	6

Molecular Basis of Cell Structure and Function (6 ECTS) link

The course aims to provide students with the essential information about the organisational plan of eukaryotic and prokaryotic cells. In particular, it provides basic references on cellular structures, the basal metabolism of nucleic acids, proteins, and cellular lipids. Additionally, using the cellular and molecular

knowledge acquired during the course, it will be possible to learn about some biotechnological applications developed in recent years.

Cellular and Molecular Dynamics (6 ECTS) link

The course aims to provide students with knowledge of cellular dynamics, with particular reference to the mechanisms of signal transduction and protein trafficking. The course will provide fundamental knowledge of the structure and function of intracellular structures present in the eukaryotic cell and the molecular basis of the physiological processes in which they are involved. Finally, the course aims to provide students with the tools necessary to understand and interpret scientific data from international literature.

Organic and Biological Chemistry (6 ECTS) link

The course aims to provide students with the fundamental concepts of the chemical basis of biological processes. The main chemical classes and their reactivity are discussed. Then, biological macromolecules and their molecular interactions in the cellular environment, the structure and dynamics of proteins in relation to their possible functions, as well as the main metabolic pathways are examined. At the end of the course, the student will be able to understand the principles underlying the structure, function, and interaction of the main organic and biochemical processes.

Experimental Biochemistry (6 ECTS) link

The main objective of the course is to provide the tools to study and understand the structure, function, and interaction of macromolecules in living organisms. At the end of the course, the student will be able to understand the most common and recent techniques for studying biological macromolecules and their interactions, plan experiments aimed at the separation and identification of complex mixtures of macromolecules, analyse protein folding and misfolding using computational techniques, as well as the interaction with small molecules of pharmacological interest.

Laboratory of Biological Data Mining (6 ECTS) link

The goal is to provide theoretical knowledge of the specific techniques developed for the mining of genomic and transcriptomic data, and the practical skills to preprocess and apply mining techniques to biological data. At the end of the module, students will be able to remember and discuss the techniques presented, read scientific literature on similar techniques, preprocess and apply mining techniques to specific types of data, and report and present the results.

Year 2 Semester 1 (Arts) – MOME		30 ECTS
Semester	***Courses***	***ECTS***
1	Artistic research with tech/bio specialisation	15
1	Prototyping and Material Studies	5
1	Visualisation and Storytelling	5
1	Interactions	5
1	Project development design (Elective course)	5

Artistic research with tech/bio specialisation (15 ECTS) new

The learning objectives for the course "Artistic Research" have two distinct specialisations: one centred around design technologies (3D printing, digital manipulation, IoT, wearables etc.), and the other focused on BioDesign. The course will cover topics such as co-design, making futures, embodied interactions, and critical thinking. Both specialisations will culminate in a final project where students will apply the skills and knowledge acquired throughout the course, showcasing their mastery of the chosen direction while integrating the themes of co-design, making futures, embodied interactions, and critical thinking.

Specialization: Design Technologies

Students will explore the aesthetic, ethical, and societal dimensions of incorporating technology into artistic practices by critically analysing digital design methodologies. The goal of the course is to foster comprehension of both digital and analog techniques within the realms of design, creativity, and research activities. Through this exploration, the curriculum will facilitate the transition towards forward-looking design approaches, enabling students to delve into evolving research on material manipulation that adeptly responds to anticipated challenges by progressing from traditional analog design/artistic procedures to advanced technologies. Furthermore, the purpose of the courses is to equip students preparing for their diplomas with a broader and updated methodological understanding of design practices, creativity, and research-development activities. This, in turn, empowers them to embark on self-directed, experimental aspects of conceptual development. The curriculum prepares students for the pragmatic and experimental utilisation of lifelong material technologies and independently updated information sources, both pivotal in evolving and refining design concepts. Of equal significance is the reinforcement of rhetorical components in multimodal communication—encompassing verbal, non-verbal, gestural, and

human-machine communication—as well as the seamless integration of wide-ranging media literacy. These proficiencies are indispensable for thriving in the ever-evolving landscape of contemporary digital design, ensuring competitiveness and relevance. Throughout the track, students can engage in interdisciplinary collaborations, blending design technologies with other artistic disciplines to foster creative cross-pollination. Reflective practice will be emphasised, enabling students to adapt their approaches based on self-assessment and produce a refined portfolio element that demonstrates mastery in integrating design technologies. The track will culminate in a final project where students will apply the skills and knowledge acquired throughout the course, showcasing their mastery of design technologies while integrating the themes of co-design, making futures, embodied interactions, and critical thinking.

Specialisation: BioDesign

In the Biodesign specialisation, students will explore the foundational principles of biologically inspired creative project development, emphasising systems thinking across other nature-based solutions (NbS). Biotechnology's potential to address pressing global challenges such as climate change, food security, and energy stability is evident. However, for these sustainable solutions to have a meaningful impact, their adoption by individuals and societies necessitates understanding industrial dynamics alongside human societies and cultures. The contemporary landscape increasingly leans on sustainable biotechnological solutions in domains like energy, food, industry, and architecture, demanding competencies in biology, chemistry, and computer science, even in sectors where these disciplines were previously ancillary. Empowering the youth to thrive amidst the green and digital transitions mandates furnishing them with the knowledge, skills, and competencies to navigate creatively and collaboratively across diverse fields and sectors. This innovative educational approach bridges this gap by arming students with broader skill sets rooted in real-world needs and concerns. It integrates novel concepts and skills into existing professions, ensuring students are prepared for this evolving landscape. The courses delve into the intricate interplay of biodesign, ethics, and ecological consciousness. Through hands-on engagement with biodesigned projects, students will not only conceptualise but also actualize artistic visions that harmonise biology, technology, and societal considerations. As students navigate the fine line between innovative artistic expression and responsible biological manipulation, ethical dimensions will be at the forefront.

Prototyping and Material Studies (5 ECTS) new

In this engaging course, students will explore the intersection of prototyping and material studies, guided by the philosophical underpinnings of Object-Oriented Ontology (OOO) and Action Network Theory (ANT). Through this exploration, students will gain a profound grasp of these theories while acquiring the practical skills to transform concepts into tangible prototypes. They will learn to critically analyse the relationships between objects, materials, and their intricate networks, applying OOO and ANT principles to interpret complex contexts. Students will master the art of prototyping by selecting suitable materials and technologies considering ethical and ecological implications. Students will leverage the opportunities presented by the somaesthetic experiences at MOME Technological Park. Cultivating perspectives and practical knowledge by engaging with the material reality within this innovative environment and collaborating closely with industry experts. These experiences will be transformative, equipping students with fresh insights that will significantly inform their final diploma projects. This unique confluence will support students to connect further the gap between theory and practice, enhancing their final projects' impact. By immersing themselves in this material practice, students will expand their horizons and deepen their understanding of the intricate interplay between theory, materials, and practical application.

Visualisation and Storytelling (5 ECTS) new

Students will delve into the art of data visualisation and storytelling, discovering how to transform intricate data into captivating narratives. Exploring the realm of tangible data and data physicalisation, students will profoundly comprehend the communicative potential of these techniques. Rooted in theoretical foundations encompassing semiotics and narrative structures, students will master the art of crafting coherent and emotionally resonant narratives around complex data sets. By translating abstract data into tactile experiences and integrating principles of plot development, character arcs, and thematic exploration, students will create informative and engaging narratives for their final projects. The course will culminate in creating and presenting a compelling visual narrative that showcases students' prowess in transforming data into impactful stories, leaving them well-equipped to communicate complex information effectively.

Interactions (5 ECTS) new

In this dynamic course, students will delve into the multifaceted realm of interactions, exploring the vital nexus between Human-Computer Interaction (HCI), design disciplines, and the fundamental aspect of crafting experiences tailored to human needs. As they navigate this landscape, students will cultivate a

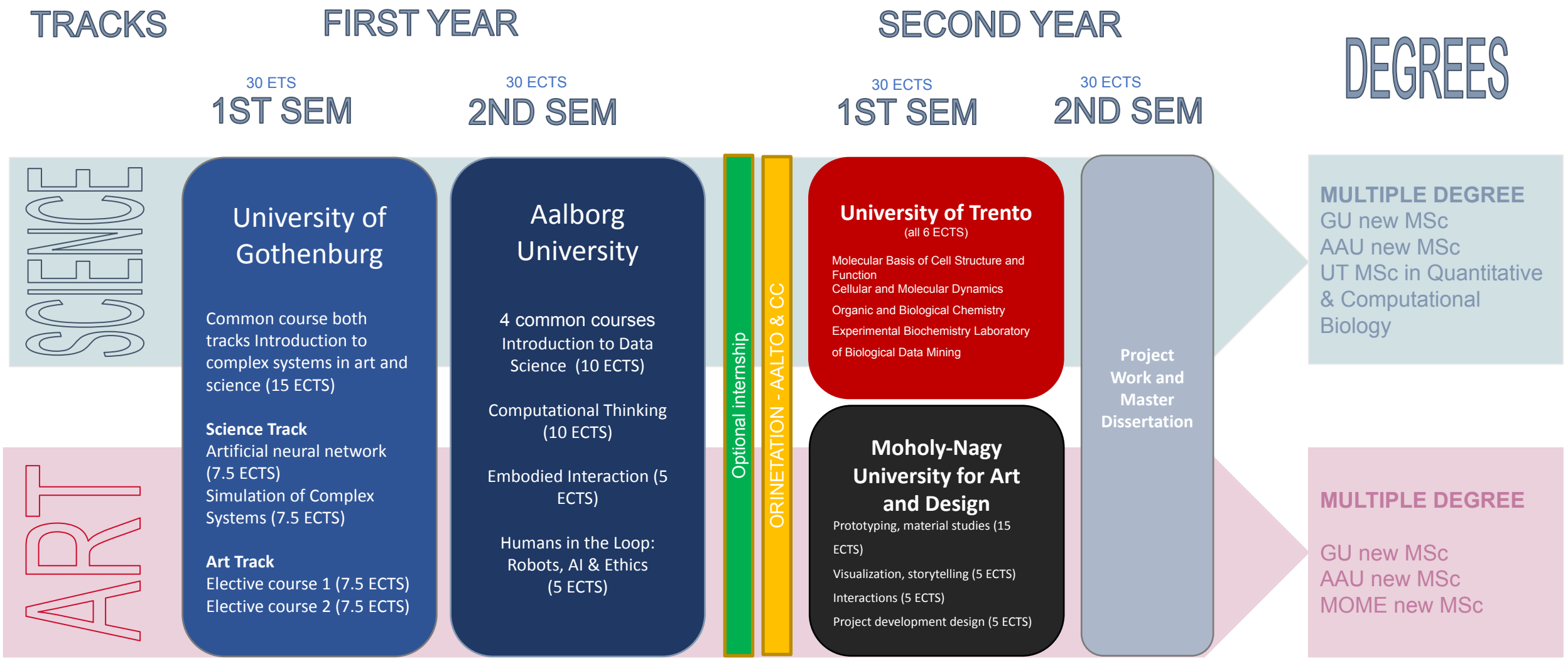
profound understanding of the intricate connections between HCI and design, recognizing how technology interfaces seamlessly with various design disciplines. The constant interplay between design and human experiences is central to the exploration, underpinning the essence of human-centred design. By immersing themselves in the foundations of HCI, students will acquire the skills to envision and implement user experiences that harmoniously blend functionality with the intricate tapestry of human needs and expectations. Moreover, this course will unravel the socio-political dynamics underlying interactions, prompting students to assess the societal implications of design choices critically. An integral facet of the journey is Design for Social Innovation and Sustainability (DESIS), which challenges students to harness their creative prowess to address complex future societal challenges. Through project-based learning, interdisciplinary collaboration, and real-world exposure, students will emerge adept at crafting interactions that transcend mere functionality, embody human experiences, and contribute to a more inclusive and empathetic world.

Project development design (Elective course) (5 ECTS) new

In this preparatory course, students will explore project development design, uncovering the intricate synergy between tangible artefacts and theoretical frameworks. With a specific focus on preparing students for their final projects in the subsequent semester, this course is a supporting stepping stone. Throughout the journey, students will develop a comprehensive understanding of how artefacts serve as vital nexuses of theoretical concepts, seamlessly blending design practice with academic inquiry. This course is strategically designed to equip students with the skills and knowledge to plan and execute their upcoming diploma projects effectively. Through hands-on project development, students will hone the ability to translate abstract theories into tangible installations and impactful creations, ensuring transition to the subsequent diploma project. As students navigate this course, they will acquire the necessary tools to meticulously plan and confidently execute the practical aspects of their diploma projects in the upcoming semester.

Year 2 Semester 2 – Master Thesis		**30 ECTS**
Semester	***Courses***	***ECTS***
2	**Project Work and Master Dissertation**	30

Erasmus Mundus Joint Masters "ABRAx"	**120 ECTS**


TRACKS
FIRST YEAR
SECOND YEAR
DEGREES
30 ETS
1ST SEM
30 ECTS
2ND SEM
30 ECTS
1ST SEM
30 ECTS
2ND SEM
SCIENCE
ART
University of Gothenburg
Common course both tracks Introduction to complex systems in art and science (15 ECTS)
Science Track
Artificial neural network (7.5 ECTS)
Simulation of Complex Systems (7.5 ECTS)
Art Track
Elective course 1 (7.5 ECTS)
Elective course 2 (7.5 ECTS)
Aalborg University
4 common courses Introduction to Data Science (10 ECTS)
Computational Thinking (10 ECTS)
Embodied Interaction (5 ECTS)
Humans in the Loop: Robots, AI & Ethics (5 ECTS)
Optional internship
ORINETATION - AALTO & CC
University of Trento
(all 6 ECTS)
Molecular Basis of Cell Structure and Function
Cellular and Molecular Dynamics
Organic and Biological Chemistry
Experimental Biochemistry Laboratory
of Biological Data Mining
Moholy-Nagy University for Art and Design
Prototyping, material studies (15 ECTS)
Visualization, storytelling (5 ECTS)
Interactions (5 ECTS)
Project development design (5 ECTS)
Project Work and Master Dissertation
MULTIPLE DEGREE
GU new MSc
AAU new MSc
UT MSc in Quantitative & Computational Biology
MULTIPLE DEGREE
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MOME new MSc