

Ph.D Programme in Computer Science at UCU¹

White Paper

Abstract. This white paper outlines the proposal of the Ph.D Programme in Computer Science at the Faculty of Applied Sciences of Ukrainian Catholic University. This proposal presents the motivation to open the Programme, with the objectives put in the contemporary national and international contexts. It outlines the structure and design of the Programme that are based on the principles of research orientation, cross-cultural and human values, professional ethics, cooperation with academia and industry at national and international scale, a proper balance of educational and research components, and individual teaching and learning with the use and timely alignment of individual learning trajectories. The paper outlines the proposed Curriculum, explains the design of the Programme, presents the view on the organisation of cooperation with academia and industry, and outlines the management structure of the Programme.

Introduction

This white paper presents an outline of the Ph.D Programme (further mentioned as Programme) in Computer Science at the Faculty of Applied Sciences of Ukrainian Catholic University (UCU). The paper is structured as follows. Our motivation and objectives are presented in Section 1. Sect. 2 elaborates the conceptual structure of the Programme by describing its basement, pillars, and crown. Sect. 3 outlines the courses and activities to be included in the curriculum. Sect. 4 further details the design of the programme by presenting its high-level architecture and pointing out how cross-cultural and ethical aspects are taken into account. Further, the view, on how cooperation with academic and industrial institutions is seen, is presented in Sect. 5. Sect. 6 outlines the proposal of the management structure of the Programme. Finally, conclusive remarks are given and further steps outlined in Sect. 7, which concludes the paper.

1 Motivation and Objectives

The current trend for Ukraine, supported and promoted by the Nation and State, is its steady movement to the membership in the European Union (EU). One of the important objectives on this way is to become an important player and integral part of the knowledge-based EU economy. To meet this objective, the system of higher education in Ukraine has to be systematically improved, refined, and strengthened in order to meet the required level of quality and share common values. One of the commonly used markers, indicating the quality of education, is the ability of the graduates to take part in and run research and development at international scale and corresponding quality level. To enable the movement towards research orientation in higher education, Ukraine requires professionals possessing increased and refined capabilities. Those could be produced at Universities, UCU in particular, using their Ph.D programmes.

1.1 Background

In the last decade, UCU has proven to be successful in providing well-educated and motivated professionals for national and international labour markets in Academia and the IT sector of industry. This success has been achieved via the establishment of the high-quality educational environment at the B.Sci and, especially, M.Sci levels. This environment is composed of the Bachelor Programme in Computer Science and International Masters Programme in Computer Science with a focus on Data Science. Both programmes are implemented using competent UCU and international academic staff and in strong cooperation with the constellation of IT companies that operate at international scale. Due to these achievements, both B.Sci and M.Sci Programmes are highly reputable and popular in Ukraine, and gain reputation internationally, via extensive and effective collaboration with Academia and Industry in Europe and overseas.

¹ Ukrainian Catholic University, Faculty of Applied Sciences (<https://apps.ucu.edu.ua/en/>).

1.2 The Gap and Opportunities

To facilitate the achievement of the aim of European integration, Ukrainian Universities have to strengthen their facility toward producing motivated and research-oriented professionals. At the UCU Faculty of Applied Sciences, the gap, to be narrowed toward the aim, is completing the design of the educational environment by designing and deploying its 3-d level – a research-oriented Ph.D Programme in Computer Science with a focus on Intelligent Systems. Remarkably, the transition period, though complex, offers numerous opportunities related to international academic and industrial cooperation and funding. This is valid because both Ukraine and international partners, including the EU, share common goals with respect to the integration of Ukraine.

1.3 Programme Objectives

With a goal to bridge the outlined gap and actuate opportunities, the Programme is designed in a way to serve as a facilitator and organisational hub that helps reach several important objectives by a motivated student, UCU as a University, Ukrainian academic and relevant industrial sectors at national and international scale, given the contemporary societal, sectoral, and professional contexts.

For a Student, the relevant objectives are seen as follows: Receive a Ph.D in Computer Science that strongly facilitates having competitive advantage while applying for senior research positions in academia and IT industry. Obtain the necessary competences and skills for successfully building their career and produce contributions to the State of the Art and Technology in academic or industrial research and development. Build professional contacts and peer network via taking active part in collaboration with Academia and Industry at national and international scale.

For UCU, the relevant objectives are seen as follows: Complete the full cycle of higher education by introducing the third (Ph.D) level. Enable further improvement of education at B.Sci and M.Sci levels via forming the pool of research-oriented staff graduating from the Programme. Improve and strengthen the competencies of the faculty due to the emerging competition with the new colleagues coming from the Programme. Systematically broaden and strengthen the professional networks of the faculty via international academic and industrial cooperation, facilitated by the Programme.

At national scale, the relevant objectives are seen as follows: Contribute to the modernization of the economy toward knowledge-based industrial development. Offer highly qualified and proactive research scientists and engineers, with strong and extensive international professional links, for National Academia and Industry sectors to provide for their competitive advantage. Contribute to the increase in the impact of value-based mind-sets and human-centric attitudes in private and public sectors. Based on these, further increase and strengthen the reputation of UCU as one of the valued actors within the National and International Academic sectors.

At international scale, the relevant objectives are seen as follows: Facilitate to the creation of the environment that systematically enables steady transition and integration of Ukrainian Academia and Industry into the common European space by producing well-educated research and development professionals in Computer Science. These professionals will possess highly demanded competences and skills, their international professional network of peers, and have motivation and experience for the effective and efficient use of international collaborative instruments, such as projects, programs, exchanges, etc.

2 The Three Pillars

In contrast to the lower level educational programmes, which are more heavily based on instruction and supervision, at the Ph.D level we aim at bringing students up through guiding, suggesting, mentoring, and providing opportunities. This is approached in a fair, clear, and logical way that ensures equal rights, inclusiveness, opportunities, and responsibility for students and the involved academic staff in partnership. The conceptual design of the Programme, outlined below, is organised in a way to promote this fairness, inclusiveness, clarity, and equality.

Basement – Ramp-up: Ramping-up students of differing backgrounds to the aligned entry level of world and professional outlook, based on human values, ethics, philosophy, and methodology of science. Providing the required set of professional and soft skills and capabilities for the further productive advancement in the Programme. Offering an opportunity to select the direction and focus

of Ph.D research in consultations with potential mentors. Shaping out a Ph.D project proposal together with the selected mentor, including a thorough review of the related State-of-the-Art in the selected field of research.

Pillar 1 – Research Orientation: Learning how to propose, apply for, and take part in research projects. Organising individual Ph.D research as a project, also by providing the required facilities. Monitoring the progress in Ph.D research projects in regular internal meetings and workshops. Cooperating with partner research groups in joint national and international research projects.

Pillar 2 – Networking and Dissemination: Offering student secondments as short research visits to partner research groups at the Universities that cooperate with the Programme. Publishing in relevant international scholarly journals. Presenting and publishing at relevant international scholarly conferences and workshops.

Pillar 3 – Involvement in Academia and Industry: Orchestrating properly balanced part-time engagements or secondments at the academic institutions and industrial companies that cooperate with the Programme. Enabling this work in industry helps collect practical requirements for the further technology transfer of the results of a Ph.D project to industry. Facilitating the elaboration of the use cases for the evaluation of Ph.D project results in real-world settings. Consulting students on the opportunities of potential industrial professional carriers.

Crown – Successful Accomplishment: Ensuring and controlling that the Programme Pillars are successfully erected on the proper Basement by each Ph.D student, following their individual trajectory. Consulting on Ph.D Thesis writing, following the best academic practices and traditions. Assisting in organising Ph.D defences and further certification at the relevant national bodies.

3 Curriculum Outline

The courses in the Curriculum are offered as a menu for a student to form their individual learning trajectory through the Programme. As students could be having different educational backgrounds and knowledge levels, they could either include a Full Course or and Advanced Part of a course in their trajectory. Nevertheless, the Programme is designed to assure that the complete set of competences and skills is acquired by every student. Therefore, the examination for an Advanced Part will also cover the topics of the corresponding Basic Part of the course.

While forming their individual learning trajectory, a student is suggested to consult with the Programme administration in order to find out how to form the trajectory in the most effective way.

3.1 Components

The Curriculum combines the educational (**EDU**) and research (**RES**) components of the Programme in a way to allow a student to be facilitated by their synergy. The nomenclature is listed in Table 1. The educational component provides the courses and activities that allow a student to acquire the required competencies and skills for their successful accomplishment of the Research component. The research component is focused on performing a Ph.D project. It also provides the necessary feedback for a student to properly form or adjust their individual learning trajectory and research output.

3.2 Courses and Activities

The courses in the Curriculum, are grouped in five categories to cover all the objectives in different Programme building blocks (Basement, Pillars, and Crown), as partial fulfilments. These categories are:

- General Knowledge, Erudition, Values, World Outlook, and Soft Skills
- General Professional Disciplines
- Specialisation Disciplines
- Secondments / Placements / Practice
- Ph.D Research Project

In the terms of earned credits, the categories are balanced. Furthermore, students are given freedom to choose either the part of a course (Basic or Advanced) or the whole course from the list (for Specialisation Disciplines) for their individual learning trajectories. This freedom is offered with an

aim to align different educational backgrounds, while guaranteeing the complete coverage of the Curriculum at the end of the Program. This coverage is seen in the competencies and learning outcomes gained through a learning trajectory.

Table 1: The courses and activities in the Ph.D Curriculum

No	Building Block	Course / Activity	Basic Part (No Credits)	Advanced Part (No Credits)
EDU: General Knowledge, Erudition, Values, World Outlook, and Soft Skills				
	Basement	Cultural Studies and Human Values	2	2
	Basement	Philosophical Foundations of Science	2	2
	Basement	Professional Ethics in Research and Development	1	1
	Pillar 2	Professional Communication and Networking Practices	2	2
	Basement	Effectively Using English in Computer Science	2	2
Subtotal:			9	9
EDU: General Professional Disciplines				
	Basement, Pillar 1	Research Frontiers of Intelligent Systems: Selected Fields	---	2
	Basement, Pillar 1	Research Methodologies in Computer Science	1	2
	Basement, Pillar 1, Pillar 2	Academic Writing and Research Support Methodologies in Computer Science	1	2
	Pillar 1, Pillar 3	Quality Assurance and Standards in IT	1	1
	Basement, Pillar 3	Didactics in Computer Science	1	1
Subtotal:			4	8
EDU: Specialisation Disciplines (Free Choice)				
	Pillar 1	Research Advances and Hot Topics in Computer Vision	---	2
	Pillar 1	Research Advances and Hot Topics in Distributed Artificial Intelligence	---	2
	Pillar 1	Research Advances and Hot Topics in Data Science	---	2
	Pillar 1	Research Advances and Hot Topics in Natural Language Processing	---	2
	Pillar 1	Research Advances and Hot Topics in Knowledge Representation and Reasoning	---	2
	Pillar 1, Pillar 2, Pillar 3	An external professional course taken either from an online educational platform or partner University	---	2
Subtotal:			---	8
Secondments / Placements / Practice				
	Pillar 1	RES: Research Secondment at a Partner Research Group	---	---
	Pillar 3	RES: Internship Placement at a Partner Company / Institution	---	---
	Pillar 3	EDU: Academic Teaching Practice (UCU or Partner University)	2	2
Subtotal:			2	2
RES: Ph.D Research Project				
	Pillar 1	Ph.D Research Project Proposal Writing	---	---
	Pillar 1	Performing Ph.D Research Project	---	---
	Pillar 2	Publishing and Presenting Ph.D Project Results	---	---
	Pillar 3	Ph.D Research Progress Workshop (Monthly)	---	4
	Pillar 1-3	Ph.D Thesis Writing	---	4
Subtotal:			---	8

No	Building Block	Course / Activity	Basic Part (No Credits)	Advanced Part (No Credits)
Planning, Control, Mentoring, Accomplishment				
	Crown	Building and adjusting individual learning trajectories	---	---
	PM	Mentoring students in Ph.D projects	---	---
	PO	Managing Ph.D research projects	---	---
	Crown	Annual attestation	---	---
	Crown	Ph.D Defence	---	---
Subtotal:			---	---
Total:			15	35

The last block of the Curriculum is focused on managing and mentoring students and their projects. This block is coordinated by the Programme Management (Sec. 6.2).

4 Architecture and Ethics

Based on the Programme objectives, design Pillars, and Curriculum outline, it is now explained how these could be bundled in a coherent teaching and learning environment that is efficient, effective and comfortable for all involved roles.

4.1 Programme Architecture

The major didactic instrument used in the program is individual teaching, learning, and mentoring on the path of an individual learning trajectory for each enrolled student. Therefore, the Programme is loosely designed for being flexible to accommodate these individual learning trajectories in the most effective and efficient way. Due to this design principle, the architecture fixes only the timeframes of the courses and activities of the actors in the Programme, as pictured in Fig. 1. The rest of the details are elaborated within an individual learning trajectory and frame out an individual projection of the Programme on the Student's path to its successful accomplishment.

Another aspect is the full compliance of the Programme with the Ukrainian National Standard of the Third Level of Higher Education in Computer Science [1].

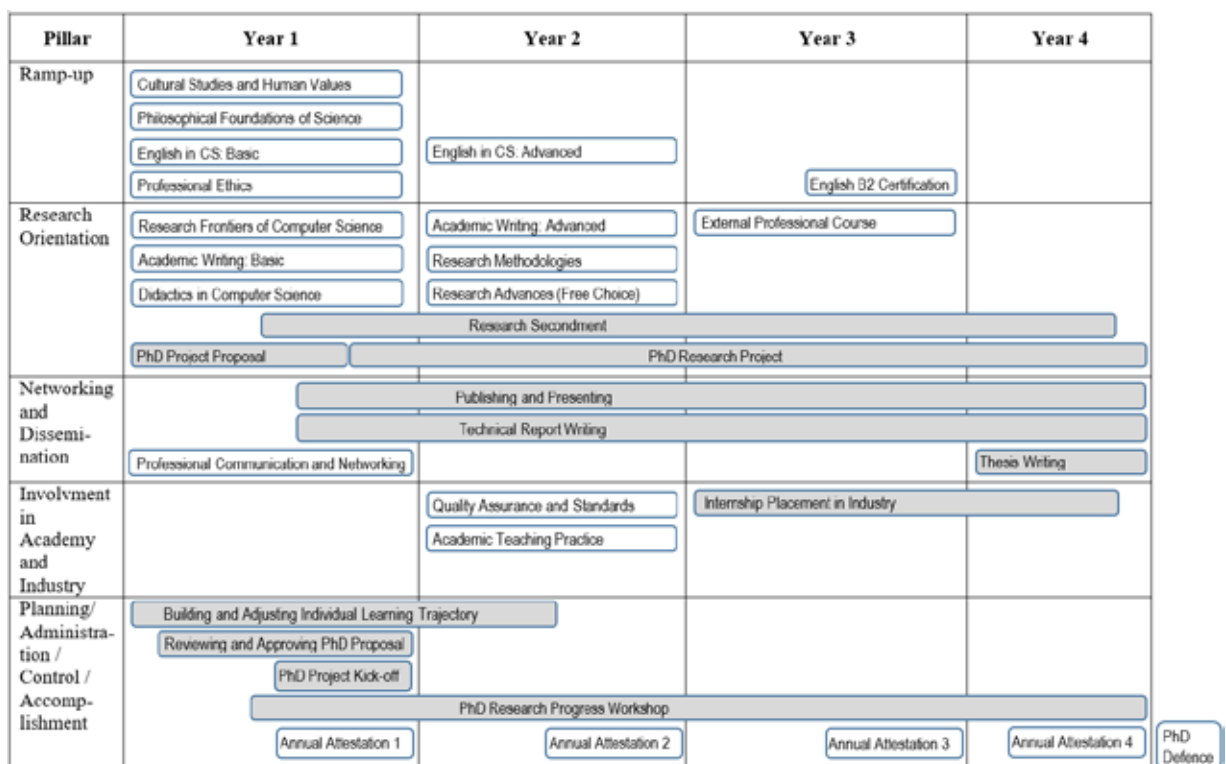


Figure 1: Courses and Activities, Grouped in Pillars, on the Timeline. **RES** activities are grey-coloured.

An initial version of the individual learning trajectory for each student is elaborated at the beginning of Year 1 in the consultations with the Programme Management and covers the Ramp-up (Basement) courses, needed to provide the knowledge required for choosing the topic and mentor. Further, the details of their individual learning trajectory are elaborated in a Ph.D Project proposal in Year 1 of the Programme, and are as follows:

- The justification for the focus and topic of the individual Ph.D research project
- The plan for the Ph.D research project
- The selection of the mentor for a Ph.D student
- The outline of the student's preferences of partner research groups, industrial companies or institutions for co-mentoring (if deemed appropriate), secondments, internships, and academic practice
- The selection of the courses (including the choice of a Basic, or Advanced part, or both) based on the educational background of the student, while ensuring that all the capabilities and learning outcomes required by the Educational Standard [1]

This Ph.D proposal is written by a student with the involvement of their chosen mentor and submitted to the Programme Management within the first three quarters of Year 1. The information and knowledge needed to produce a credible proposal is obtained in the Ramp-up (Basement) courses of the Programme.

Programme Management reviews the submitted Ph.D Proposal, requires its refinements if needed, and finally approves it. The initial version of the individual schedule for a student is also produced. Further, the Project Office of the Programme configures and kicks-off the individual Ph.D Research Project. A schedule and research project configuration could be further adjusted and refined until the middle of Year 2 to reflect scope and focus changes, the availability of secondment vacancies and funding.

In the subsequent phase of the Programme, a student fulfils the plan according to the schedule. Their overall progress is controlled and appraised, via the instrument of Annual Attestations, by Programme Management and Project Office. At the final annual attestation at the end of Year 4, the state of the fulfilment of the partial commitments is checked and decision is made about the admission of a student to defend their Ph.D. All admitted students are assisted by the Programme Management in the organisation of their defence and further endorsement of the degree by the respective Ukrainian national bodies.

In the case of official co-mentorship and respective legal binding, the defence could be done at the corresponding Partner Institution in Ukraine or abroad. In the latter case, the Programme will assist the recipient of a foreign Ph.D diploma in the process of its nostrification in Ukraine, if requested.

4.2 Cultural Sensitivity, Diversity, Inclusion, and Ethics

It is assumed that the Programme will produce graduates that are ready to operate in globally distributed, multi-national, and therefore multicultural working environments. Hence being knowledgeable of and in possession of practical skills for working comfortably in these settings is of utmost importance for our students. The Programme is designed to start teaching cultural sensitivity and diversity aspects in its Year 1, within its Ramp-up (Basement) phase – please refer to Table 1 and Figure 1. For example, the students will learn about the differences in the customs and etiquette of the people belonging to different cultures in the Cultural Studies and Human Values course. The relevant competencies and practical skills will further be consolidated in the academic secondments, industrial placements, and academic practice.

It is also important that knowledge and skills of Computer Science are made equally accessible to all people, including these with disabilities. UCU has the proper environment in place for being inclusive in that sense. Furthermore, the Programme is designed around the use of individual learning trajectories for the students. Hence, the Programme is inclusive by its environment and design.

One more important aspect is professional ethics. In particular, ethical issues are important in Computer Science (likewise in the other so to say “soft” sciences) as it intensively uses and reuses immaterial artefacts belonging to different people. Such immaterial assets like a dataset, an image, a

piece of software code, a text could be easily copied and plagiarised. The students will learn about good practices and patterns that help avoid even unintentional plagiarism in the Professional Ethics course. This knowledge will further be consolidated in their research and dissemination activities.

Overall, the Programme is designed to comply with the relevant recommendations of the ACM Computing Curricula report of 2020 [2].

5 Cooperation

Project-related activities are an essential part of the professional life of a researcher, also in Computer Science. Projects, however, do not exist in vacuum. Even if a researcher is the only person performing an individual project, a Ph.D project for instance, there are several stakeholders for it: a funding body, an early adopter, a professional community that might wish to cross-evaluate the solution, a publisher, etc. Therefore, being able to communicate and cooperate with different agents, related to a project, is an essential skill for a researcher.

The Programme offers several courses and activities that help develop this important competence and skill. On the other hand, the Programme is designed in a way to cooperate itself and, hence, provide an appropriate working pattern and cooperation-friendly environment for the students. Cooperation within the Programme is arranged and coordinated through its Bodies (Section 6) and the involvement of its partners, such as research groups in different Universities or research Institutions, industrial companies.

For the Programme, the motive to be engaged in academic and industrial cooperation is twofold, as outlined in its objectives (Section 1). On one hand, the Programme intends to ramp-up its involved faculty to be better trained, equipped, and informed about the State of the Art and Technology. Hence, working on cooperative projects with academic and industrial partners may be beneficial for the Programme staff. On the other hand, being involved in cooperation together with the students may help improve the effect and impact of education and bring new well-formed professionals to the faculty. It is also important that the Programme builds upon and keeps the balance between academic and industrial knowledge and skill inflows from the partners. Hence, a balanced constellation of academic and industrial units as the partners in cooperation would be super-additive. Indeed, the roles and contributions of academic and industrial partners are different, but mutually beneficial if orchestrated in proper balance.

5.1 Partner Research Group

A partner research group is an academic unit, affiliated with a national or foreign University or Research Institution. As a partner, such a group might wish to help the Programme in, but not limited to:

- Suggesting potentially interesting and valuable research topics for Ph.D projects, offering cooperation between a Ph.D student on the Programme and the members of the partner research group on some parts of the research agenda, where the research interests are aligned and cooperative work might be mutually beneficial. This could be done in the forms of co-mentorship, peer-to-peer collaboration, cross-evaluation, sharing resources (like datasets, etc.), and academic use-cases.
- Offering research secondments for the Ph.D students or UCU faculty involved in the Programme and coming on research secondments to UCU. This could be organised using the available internal funding, public funding (e.g. Marie Curie Programme²), or industrial sponsorship by a Partner Company (Sect. 5.3).
- Jointly taking part in international project consortia with the involvement of the Ph.D students on the Programme. This form of cooperation might be in proposal preparation and taking parts in the project if the proposal was successful and was funded.

² <https://marie-skłodowska-curie-actions.ec.europa.eu/>

These collaborative activities could be organised informally – as peer-to-peer efforts, or formally – under the binding of a cooperation agreement between UCU and the involved University or Institution.

The leaders of the partner research groups might be invited to join the Advisory Board of the Programme.

5.2 Partner University or Institution

A Partner University or research Institution is an academic or public organisation, in Ukraine or abroad, that hosts one of the Partner Research Groups to the Programme. This organisation becomes a partner to the Programme if they wish to have a formal cooperation framework that is legally binding in a Cooperation Agreement with UCU.

In addition to research secondments and collaboration (Sect. 5.1), a partner University might wish to offer the placements for academic teaching practice to the students enrolled on the Programme.

A potential avenue for the cooperation with a partner University or Research Institution is establishing a joint Ph.D Programme that opens a way to the mutual recognition of the degree and broader employment opportunities for the graduates.

5.3 Partner Company

A Partner Company is a private or public company that might wish to help the students on the Programme and its affiliated staff in, but not limited to:

- Providing part-time placements or internships in the company. Using these placements a student will perform real-world requirements elicitation and elaborate industrial use cases for their Ph.D project. The company will have an opportunity to employ the student, on a part-time basis, to do some relevant work in their industrial projects and demonstrate the opportunities for potential technology transfer of their Ph.D project contributions to the State of the Art.
- Providing the facilities and environment for the Programme. These facilities, such as computational power, software subscriptions, software development methodologies, industrial datasets, etc., will be used by the students and involved faculty in their research projects, managed by the Programme Project Office (Sect. 6.3).
- Sponsoring academic secondments of the students, enrolled on the Programme, to the Partner Research Groups

The representatives of the partner companies might be invited to join the Advisory Board of the Programme.

6 Programme Bodies

The Programme operates with the involvement of several bodies that elaborate and refine its shape, content, and activities.

6.1 Advisory Board

The ACM Computing Curricula report of 2020 [2] suggested “... that professional or industrial advisory boards are essential for the development of strong and meaningful computing programs. Professionals from industry and government are a great resource for insight on the needs of the workplace. These groups can become strong catalysts for bridging the computing program to needs of industry and government. They also establish personal connection between the computing program, its students, and the professional world.” In addition to this opinion for Undergraduate Curricula, it is believed that a pool of academics, possessing strong international reputation, in the Advisory Board would provide for strengthening a research-oriented Ph.D-level Programme.

Within the Programme, the role of the Advisory Board, as a body, and its individual members is seen in:

- Helping improve and reshape the curriculum, its courses and activities based on their experience and vision

- Suggesting the themes for Ph.D research based on their understanding of the current State of the Art and Technology in their fields of competence
- Facilitating to the involvement of the students in collaborative research activities

Based on these considerations, the Advisory Board for the Programme is proposed to comprise:

- **Academic Members:** Top- or medium-level academic researchers coming from the Universities or Research Institutions

It is supposed that the academic members of the Advisory Board lead research groups that are internationally highly visible in their research fields, relevant for the Programme. This visibility is assessed in terms of their research achievements and accomplished project, their activity in the corresponding international research communities, research project proposing, and cooperation with relevant industries. It is welcomed that the research groups of the Advisory Board members consider partnering with the Programme and accepting the students for secondments, provided that there is available funding. Academic Advisory Board members might be invited to give tutorials or lectures within the courses of the Programme.

- **Industrial Members:** Medium- or senior-level Research and Development staff coming from the relevant companies

It is supposed that the industrial members of the Advisory Board are in positions that impact shaping out the technological future of their companies. Consequently, they are experienced and knowledgeable in what are the technology frontiers in their industrial sectors and what could be a valuable proposal and contribution for the technology transfer that may strengthen the competitive advantage of their company within the sector. It is welcomed that the industrial members of the Advisory Board facilitate organizing part-time internships / placements for the students on the Programme in their companies. These placements are deemed mutually beneficial in terms of elaborating the case studies to trial the contributions of Ph.D projects in real-world industrial settings. Academic Advisory Board members might be invited to give tutorials or lectures within the courses of the Programme.

The Advisory Board is supposed to have regular quarterly meetings to discuss their agenda and elaborate recommendations for the Programme and its Management.

6.2 Programme Management

Programme Management staff is responsible for the coordination, control, and supervision of all the courses and activities in the Programme. It comprises a Programme Director and their Operations Assistant. In addition to management, the Programme Management is in charge of disseminating the information about the Programme, establishing relationships with Programme partners, organizing the enrolment of students. Programme Management reports to the Dean of the Faculty of Applied Science and, indirectly, to the senior management of UCU.

6.3 Project Office

The Project Office is the unit that coordinates all project-related activities within the Programme, such as Ph.D research projects by the students enrolled on the Programme and collaborative projects with partner research groups and companies. It also assists in organising and running collaborative projects at the Faculty of Applied Science, if requested by the faculty or Faculty management. Project Office is the hub that orchestrates cooperative activities between the Programme, its students, partner research groups, and companies, such as incoming and outgoing research secondments, industrial placements, and academic practice secondments. The staff of the Project Office comprises the Head of the Office and Technical Assistant. The Head of the Office reports to Programme and Faculty management.

Conclusive Remarks

This white paper presented our high-level vision on how a Ph.D Programme in Computer Science (Intelligent Systems) at UCU could be shaped out to become a potentially successful 3-d level research-oriented university programme in the contemporary Ukrainian and relevant international contexts. The features put into the basis of the Programme are its research orientation, cross-cultural and human values, professional ethics, cooperation with academia and industry at National and

International scale, a proper balance of educational and research components, and individual teaching and learning with the use and timely alignment of individual learning trajectories.

References

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2. Clear, A., Parrish, A., et al.: Computing Curricula 2020 (CC2020): Paradigms for Global Computing Education. Association for Computing Machinery (ACM) & IEEE Computer Society (IEEE-CS), December 31, 2020, DOI: 10.1145/3467967 (<https://dl.acm.org/citation.cfm?id=3467967>).