SYLLABUS

1. Data about the program of study

1.1	Institution	The Technical University of Cluj-Napoca
1.2	Faculty	Faculty of Automation and Computer Science
1.3	Department	Computer Science
1.4	Field of study	Computer Science and Information Technology
1.5	Cycle of study	Master of Science
1.6	Program of study/Qualification	Data Science / Master
1.7	Form of education	Full time
1.8	Subject code	7.3

2. Data about the subject

2.1	Subject name			***Advanced Topics in Functional Programming***			
2.2	Course responsible/lecturer			Conf.Dr.Ing. Slăvescu Radu Răzvan - Radu.Razvan.Slavescu@cs.utcluj.ro			
2.3	Teachers in charge of laboratories			Conf.Dr.Ing. Slăvescu Radu Răzvan - Radu.Razvan.Slavescu@cs.utcluj.ro			
2.4 Year of study	1	2.5 Semester	2	2.6 Assessment	E–exam, C–colloq., V-verif.		E
2.7 Subject category	Formative category: DA – advanced, DS – speciality, DC – complementary						DA
	Optionality: DI – imposed, DO – optional (alternative), DF – optional (free choice)						DO

3. Estimated total time

3.1 Number of hours per week	3	of which	3.2 Course	2	3.3 Seminar	-	3.3 Laborator	-	3.3 Proiect	1
3.4 Total hours in the curriculum	42	of which	3.5 Course	28	3.6 Seminar	-	3.6 Laborator	-	3.6 Proiect	14

3.7 Individual study:	
(a) Manual, lecture material and notes, bibliography	15
(b) Supplementary study in the library, online and in the field	25
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays	11
(d) Tutoring	5
(e) Exams and tests	2
(f) Other activities	-
3.8 Total hours of individual study (summ (3.7(a)…3.7(f)))	58
3.9 Total hours per semester (3.4+3.8)	100
3.10 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1	Curriculum	-
4.2	Competence	Basic knowledge of functional programming (functional style of writing functions, recursion, types, pattern matching)

5. Requirements (where appropriate)

5.1	For the course	Video projector, blackboard, screen, computer
5.2	For the seminar / laboratory / project	Computers, equipment and specific software

6. Specific competences

6.1 Professional competences	**C1 -** Working with advanced mathematical methods and models, engineering and computing specific techniques and technologies **C3 - I**nnovative design of artificial intelligence and computer vision systems and related software and hardware using the specific tools
6.2 Transversal competences	**C1 -** Proof of knowledge for the economic, ethical, legal and social context associated with the profession, for correct task identification, schedule of activities, responsible decisions, with the final goal the design, preparation and presentation of a scientific paper **C3 -** The student must carry out the testing process anf the qualitative evaluation of both functional and non-functional characteristics of computer systems, according to specific criteria. S/he also has to be able to develop systems and applications for hardware / software / communication systems use and maintenance

7. Discipline objectives (as results from the *key competences gained*)

7.1	General objective	Development of skills and abilities to apply Functional Programming principles in developing and implementing algorithms and software systems in the field of Data Science
7.2	Specific objectives	Gaining knowledge and skills within the context of Data Science aimed to: • understand and use functional concepts • study, design, implement and evaluate applications for Data Science in a functional manner

8. Contents

8.1. Lecture	Number of hours	Teaching methods	Note
Abstract Data Types	2	Interactive presentation, students involved in debates	
Monoids. Functors. Applicatives	2		
Monads and monad transformers	2		
Arrows	2		
Strategies and Eval monad	2		
Arrays, Repa and Par monad for processing large datasets	2		
Accelerate for Graphics Processing Unit (GPU)	2		
Case study: Haskell-based functional languages for blockchain smart contracts: Plutus (Cardano, 3rd generation blockchain platform), Daml (Digital Assets Modeling Language)	2		
Basics of Category Theory	2		
Basics of Category Theory II. Case study: Category Theory for Quantum NLP	2		
Purity of expressions in a quantum program. Case study: Twist Language (MIT new Quantum Computing language)	2		
Compositionality: JAX for high-performance numerical computing	2		
Function type: TensorFlow Federated	2		
Lazy evaluation: Lazy decomposition and conciliation. Robot motion planning	2		

Bibliography

1. Bryan O'Sullivan, John Goerzen, Don Stewart. Real World Haskell. O'Reilly Media, 2008
2. Simon Marlow. Parallel and Concurrent Programming in Haskell. O'Reilly Media, 2013
3. C. Olah. Neural Networks, Types, and Functional Programming
4. Thinc: A refreshing functional take on deep learning, compatible with your favorite libraries
5. Alexis Toumi. Category Theory for Quantum Natural Language Processing. 2022
6. Xi Cheng, Min Zhou, Xiaoyu Song, Ming Gu, Jiaguang Sun. Parallelizing SMT solving: Lazy decomposition and conciliation. 2018. 10.1016/j.artint.2018.01.001.

   https://cxcfan.github.io/pub/1-s2.0-S0004370218300237-main.pdf
7. Generalized Lazy Search for Robot Motion Planning: Interleaving Search and Edge Evaluation via Event-based Toggles
   https://personalrobotics.cs.washington.edu/publications/mandalika2019gls.pdf
8. Charles Yuan, Christopher McNally, Michael Carbin. Twist: Sound Reasoning for Purity and Entanglement in Quantum Programs. Proceedings of the ACM on Programming Languages, Vol 6, Issue POPL, article no. 30m pp 1-32. 2022

8.2. Seminars /Laboratory/Project	Number of hours	Teaching methods	Notes
Application design (goals, tools, evaluation metrics)	2	Implementation using specific software tools, experiments and performance evaluation	
Application Implementation	4		
Testing. Refactoring	2		
Performance Evaluation according to the chosen metrics	3		
Writing the final report	3		

Bibliography

1. https://docs.discopy.org/en/main/
2. https://www.tensorflow.org/federated/get_started
3. http://www.serpentine.com/criterion/
4. https://github.com/google/jax/blob/main/README.md
5. https://pytorch.org/functorch/stable/

9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

It is carried out through periodic meetings with representatives of the economic environment

10. Evaluation

1	Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
	10.4 Course	Exam	Written examination	50%
	10.5 Project	Practical abilities to solve the problems and to implement specific applications Attendance and activity.	Project: continuous assessment (according to the milestones set)	50%
	10.6 Minimum standard of performance: Both, Written examination and Oral examination, marks are bigger or equal with 5			

Date of filling in:		Title Surname Name	Signature
	Lecturer	Conf.Dr.Ing. Slăvescu Radu Răzvan	
	Teachers in charge of application	Conf.Dr.Ing. Slăvescu Radu Răzvan	

Date of approval in the department 20.02.2024	Head of department Prof.dr.ing. Rodica Potolea
Date of approval in the faculty council 22.02.2024	Dean Prof.dr.ing. Mihaela Dinsoreanu