The Impact of Resource Allocation on the Machine Learning Lifecycle

Bridging the Gap between Software Engineering and Management

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Appendix (available online via http://link.springer.com)

Appendix A

Table 4. Concept Matrix of the Literature Analysis

	Data Storage Infrastructure	Training Infrastructure	Deployment Infrastructure	Security Mechanisms	Raw Data	Pre-processed Data	Production Data	Hardware Evaluation Tools	Data Management Tools	Data pre-processing Tools	Feature Engineering Tools	Model Management Tools	Application/User Interface	Pre-Trained ML Model	Configured ML Model	Trained ML Model	Serviced ML Model
Aboueata et al. (2019)												x					
Abubakar et al. (2020)						x			x	x							
Agrawal et al. (2019)	x	x			x	x			x	x	x				x		
Amershi et al. (2019)				x	x				x			x	x	x			
Arpteg et al. (2018)	x	x		x	x	x	x	x				x			x	x	
Baier and Seebacher (2019)		x	x			x	x		x	x		x			x		x
Balayn et al. (2021)						x			x	x	x		x			x	x
Belani et al. (2019)					x	x										x	
Bhattacharjee et al. (2017)		x	x	x		x				x		x	x			x	
Boag et al. (2018)		x	x					x							x		
Duong and Sang (2018)		x						x							x		
Fujii et al. (2020)									x						x		
Giray (2021)		x			x	x			x	x	x						
Haakman et al. (2021)		x	x		x	x	x	x	x	x	x	x				x	x
Hesenius et al. (2019)					x				x		x	x			x		
Hill et al. (2016)											x						
Hutchinson et al. (2021)									x	x							
Idowu et al. (2021)		x							x	x		x	x		x	x	
Javadi et al. (2020)	x	x	x		x	x										x	
John et al. (2020)		x			x	x										x	x
Jöhnk et al. (2021)	x	x	x				x									x	
Hazelwood et al. (2018)		x	x			x		x		x	x					x	
Kumeno (2020)		x	x	x		x			x	x	x	x	x			x	x
Lins et al. (2021)				x	x				x	x					x		x
Lwakatare et al. (2020)					x		x		x	x	x		x			x	
Mikalef et al. (2019)	x																
Mikalef and Gupta (2021)	x	x			x	x	x	x									
Nascimento et al. (2019)					x	x				x	x				x	x	
Nguyen et al. (2019)		x						x	x	x	x			x	x		
Papagiannidis et al. (2021)		x			x	x										x	
Philipp et al. (2020)				x	x	x			x	x			x	x		x	x
Polyzotis et al. (2018)		x			x		x		x	x							
Reimann and Kniesel-Wünsche (2020)						x			x	x	x				x	x	
Ribeiro et al. (2015)					x				x			x	x	x	x	x	x
Saldamli et al. (2021)		x										x	x	x	x		x
Schmidt et al. (2020)		x	x			x					x					x	
Sculley et al. (2015)					x	x			x			x			x		
Someh et al. (2020)					x	x	x		x	x							
Wamba-Taguimdje et al. (2020)		x			x							x					
Washizaki et al. (2019)						x						x	x	x		x	x
Whang and Lee (2020)	x				x	x			x	x					x	x	
Yao et al. (2017)									x	x		x			x		x
Yi et al. (2020)	x	x	x		x											x	x
Yu et al. (2020)		x	x	x											x		

Appendix B

Table 5: Design Iterations of Framework

Phase	Empirical basis	Iteration description	dopted framework structures	Evaluation Method	Fulfilled evaluation criteria (Sonnenberg and vom Brocke 2012)	Unfulfilled evaluation criteria (Sonnenberg and vom Brocke 2012)
Iteration 1	Literature	Initial framework design on the basis of resources and influencing factors mentioned in the literature. Broad categorization of resources into: • Data • Infrastructure/hardware • Technical implementation • Residual category	Vertical structuring of resources as proposed by Lins et al. (2021)	Criteria-based evaluation		• Understandability • Internal consistency • Completeness • Varying level of detail
Iteration 2		Mapping of resources according to the ML lifecycle as proposed by Ashmore et al. (2021) and Amershi et al. (2019) Introduction of effect classes (indirect and direct) as well as effect types (supplementing, iterating, reusing, automating, informing, creating)	Vertical structuring of resources as proposed by Lins et al. (2021) Horizontal structuring of resources as proposed by Ashmore et al. (2021) and Amershi et al. (2019)	Criteria-based evaluation	• Internal consistency	• Understandability • Completeness • Varying level of detail
Iteration 3	Interviews (E1- E6)	Revision of the demarcation of resources: • Addition of Breeding Ground (humans' technical and business skills and glue/reusable code) • Specification of infrastructure in data, training, and deployment Rearrangement of resources: • Specification of Model Managing Tools in: ML Training Tools, Experiment Tracking Tools, Model Lineage Tools, and Model Monitoring Tools • Changes of layers in services to reflect the kind of resources: o ML Software in Software Services o Developing Tooling in Developer Services o Infrastructure in Infrastructure Services • Change of Serviced ML Model in Deployed ML Models • Integration of security mechanisms around any resources rather than representation as single resource Specification of relationships in process and effect relationships	Horizontal structuring of resources as proposed by Ashmore et al. (2021) and Amershi et al. (2019)	Interview-based evaluation	• Internal consistency • Robustness • Fidelity with real-world problem	• Understandability • Too little level of detail • Completeness

Iteration 4	Interviews (E7- E8)	Revision of vertical arrangement of the resources as well as simplification of the framework: Elimination of layers to increase preciseness of framework while adding data, training, and deployment infrastructure as base layers Specification of primary and secondary resources Introduction of missing resources: • Data repositories • Data generation tools • ML Training Tools • ML Models' Outputs • Data Quality-Enhancing Tools	Horizontal structuring of resources as proposed by Ashmore et al. (2021) and Amershi et al. (2019)	Interview-based evaluation	• Internal consistency • Robustness • Fidelity with real-world problem • Level of detail	• Understandability • Completeness
Iteration 5	Interviews (E9- E11)	Addition of human resources (data engineer, data scientist, software developer /-architect, product-/ process owner) and business (strategy and business requirements) Extradition of Glue / Reusable Code in a base layer	Horizontal structuring of resources as proposed by Ashmore et al. (2021) and Amershi et al. (2019)	Interview-based evaluation	• Internal consistency • Robustness • Fidelity with real-world problem • Level of detail • Understandability • Completeness	