Process Model Complexity Metrics, Cognitive Load and Visual Behavior: A Multi-Granular Eye-Tracking Analysis

Appendix: List of metrics

Complexity metrics

Essential complexity

Table 1 presents a subset of the metrics that have been associated to model-related characteristics in [Mendling2008] and [Mendling2012].

Category	Description	Name/symbol	References
FROM [Mendling2009]			
Size	The number of nodes in the model (e.g., tasks, gateways, events).	Size, diameter (Diam)	Mendling2008, Sanchez-Gonzalez2010, Mendling2012
Density ('Connection' in [Mendling2012])	Relates the number of edges (possible flows) to the size of the model.	Coeff. of connectivity (Conn. Coeff.), average degree of a connector (Avg d_c), maximum degree of a connector (Max d_c)	Mendling2008, Mendling2012
Partitionability ('Modularity' in [Mendling2012])	Considers the relationship of subcomponents to the overall model	Separability (Π), Sequentiality (Ξ), depth (Λ), Structuredness (Φ)	Mendling2008, Figl2011, Mendling2012
Connector interplay	Considers the interactions and effects of the different connector types	Connector Heterogeneity (CH), Control Flow Complexity (CFC)	Cardoso2006, Mendling2008, Mendling2012
Cyclicity (merged in 'Complex behavior' in [Mendling2012])	Counts the number of nodes for which a cycle exists then provide the ratio of this number to the total number of nodes of the model.	Cyclicity (CYC)	Mendling2008, Mendling2012
Concurrency (merged in 'Complex behavior' in [Mendling2012])	Explores the possible concurrent paths of a model. The Token split metrics counts the control tokens associated with the control (e.g. AND or OR) designed in the model	Token split (TS)	Mendling2008, Mendling2012

Table 1 - List of metrics addressing essential complexity.

Accidental complexity

Table 2 summarizes a list of metrics provided by [Bernstein2015] and [Burattin2017] (detailed formulas can be found in the cited studies) with name and the description of each feature category:

Categories	**Description**	**Name / Symbol**	**Reference (support the features)**
From [Bernstein2015]			
Edges style	A measure of the style of the edges as the ratio of simple (default) or 'broken' (with breaking points) edges to the total number of edges.	%simpleEdges (%sE), %brokenEdges (%bE)	[Purchase1997], [Schrepfer2009], [Effinger2010]
Crossing edges	Ratio of the number of crossing edges to the total number of edges	%totalCross (%tC)	[Purchase1997], [Schrepfer2009], [Effinger2010]
Angles	Ratio of the number of orthogonal segments to the total number of segments. *Orthogonal segments are parts of edges which are aligned with a grid layout of the model.*	%orthogonalSegments (%oS)	[Purchase1997], [Effinger2010]
Symmetry in blocks*	Symmetry of the elements' arrangement inside a block of the model.	%symmetricalPatterns (%sP)	*(See note on symmetry in blocks in the table caption)*
From [Burattin2017]			
Consistency flow	Measure how the flow (the general direction) in the model can change or not its general direction.	Metric based on behavioral profiles (M-BP)	[Effinger2010]

Table 2 - List of metrics addressing accidental complexity proposed by [Bernstein2015] and [Burattin2017].
(*) The authors in [Bernsetin2015] propose the concept of symmetry in blocks as a category of visual features that affect positively the reading/understanding of models, but did not provide any quantification.

References

Mendling2008 J. Mendling, “Detection and Prediction of Errors in EPC Business Process Models,” in Ausgezeichnete Informatikdissertationen 2007, Dagstuhl, Germany, April 2008, D. Wagner, Ed., Germany: Springer, Dec. 2008, pp. 211–218.

Mendling2012 J. Mendling, L. Sánchez-González, F. García, and M. L. Rosa, “Thresholds for error probability measures of business process models,” Journal of Systems and Software, vol. 85, no. 5, pp. 1188–1197, May 2012, doi: 10.1016/j.jss.2012.01.017.

Sanchez-Gonzalez2010 L. Sánchez-González, F. García, J. Mendling, and F. Ruiz, “Quality Assessment of Business Process Models Based on Thresholds,” in On the Move to Meaningful Internet Systems: OTM 2010, R. Meersman, T. Dillon, and P. Herrero, Eds., Springer Berlin Heidelberg, 2010, pp. 78–95. doi: 10.1007/978-3-642-16934-2_9.

Figl2011 K. Figl and R. Laue, “Cognitive Complexity in Business Process Modeling,” in Advanced Information Systems Engineering, Springer Berlin Heidelberg, 2011, pp. 452–466. doi: 10.1007/978-3-642-21640-4_34.

Cardoso2006 J. Cardoso, “Process control-flow complexity metric: An empirical validation,” in 2006 IEEE International Conference on Services Computing (SCC06), IEEE, Sep. 2006. doi: 10.1109/scc.2006.82.

Bernstein2015 V. Bernstein and P. Soffer, “Identifying and Quantifying Visual Layout Features of Business Process Models,” in Enterprise, Business-Process and Information Systems Modeling, K. Gaaloul, R. Schmidt, S. Nurcan, S. Guerreiro, and Q. Ma, Eds., Cham: Springer International Publishing, 2015, pp. 200–213. doi: 10.1007/978-3-319-19237-6_13.

Burattin2017 A. Burattin, V. Bernstein, M. Neurauter, P. Soffer, and B. Weber, “Detection and quantification of flow consistency in business process models,” Software & Systems Modeling, vol. 17, no. 2, pp. 633–654, Jan. 2017, doi: 10.1007/s10270-017-0576-y.

Purchase1997 H. Purchase, “Which aesthetic has the greatest effect on human understanding?,” in Graph Drawing, Springer Berlin Heidelberg, 1997, pp. 248–261. doi: 10.1007/3-540-63938-1_67.

Schrepfer2009 M. Schrepfer, J. Wolf, J. Mendling, and H. A. Reijers, “The Impact of Secondary Notation on Process Model Understanding,” in *Lecture Notes in Business Information Processing*, Berlin, Heidelberg: Springer Berlin Heidelberg, 2009, pp. 161–175. doi: 10.1007/978-3-642-05352-8_13.

Effinger2010 P. Effinger, N. Jogsch, and S. Seiz, “On a Study of Layout Aesthetics for Business Process Models Using BPMN,” in Lecture Notes in Business Information Processing, Berlin, Heidelberg: Springer Berlin Heidelberg, 2010, pp. 31–45. doi: 10.1007/978-3-642-16298-5_5.