**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 dc), maximum degree of a connector (Max dc) | 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. Garcı́a, 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. Garcı́a, 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. |