Validation of a generalized complexity measure

1 Background

The Capability Systems Centre (CSC) calls for EOIs from interested researchers with the suitable background and expertise to tackle the following work package in validating a generalized complexity measure.

2 Work package overview

A major research direction in the CSC is the development and use of tools and techniques for managing complexity, particularly in systems development. Towards this goal, a generalized complexity measure has been developed and shown to be applicable to any domain, particularly when applied to engineered systems (Efatmaneshnik and Ryan, 2016).

The purpose of this work package is to: (a) undertake a detailed literature review of complexity measures, and (b) show that the generalized complexity measure accommodates extant measures and does indeed provide a generalized framework for measuring complexity.

2.1 Scope

Previous considerations of appropriate measures have not directly addressed the fundamental issue that the complexity of any particular matter or thing has a significant subjective component in which the degree of difficulty depends on available frames of reference. Any attempt to remove subjectivity from a measure of complexity therefore fails to address a very significant aspect of complexity. On the other hand, there has been justifiable apprehension towards purely subjective complexity measures, simply because they are not verifiable if the frame of reference being applied is in itself both complex and subjective. Efatmaneshnik and Ryan (2016) addressed this issue by introducing the concept of subjective simplicity—although a justifiable and verifiable value of subjective complexity may be difficult to assign directly, it is possible to identify in a given context what is ‘simple’ to the observer and, from that reference, determine subjective complexity.

The generalized complexity measure proposed by Efatmaneshnik and Ryan (2016) allows the study of system complexity from the perspectives of multiple stakeholders who naturally have a diverse set of reference simplicities. In each case a candidate solution has a constant objective complexity and a number of subjective ones depending on the points of view of stakeholders. Solutions can then be compared based on:

- That with the lowest objective complexity.
- That with the lowest subjective complexity for certain stakeholders.
- That with the smallest deviation in subjective complexity over all stakeholders.

The proposed system complexity measure has the additional advantage of being adaptable in terms of subjective complexity with reference to dynamic models that evolve with the learning of observers.

2.2 Focus

While there is some considerable potential for a common measure of complexity, there are many such measures (mostly domain-specific) in the literature (McCabe, 1976; Braha and Maimon, 1998; Bashir and Thomson, 1999; Edmonds, 1999; Dierneder and Scheidl, 2001; Summers and Shah, 2003; Chen and Li, 2005; Suh, 2005; Efatmaneshnik, Reidsema, Marczyk, and Balaei, 2010; Kreimeyer and Lindemann, 2011, Tarride, 2013), with the usefulness of each measure tending to be context-specific.

Efatmaneshnik and Ryan (2016) proposed that their generalized complexity measure is applicable to any domain, and provided some examples of how the framework can be applied as a generalized version of several selected complexity measures (such as cyclomatic complexity). In this study, we aim to broaden that analysis by:

1. Drawing on existing literature to extract a complete set of extant complexity measures.
2. Showing analytically (or by simulation at least) that the proposed generalized complexity measure accommodates extant measures and does indeed provide a generalized framework for measuring complexity.

2.3 Milestones and Deliverables

Milestone #	Milestone description	Date
1	Initial workshop to establish working arrangements, further define the problem and to clarify any questions or issues from either party	Within two weeks of commencement of agreement, Location: TBD
2	Literature review and analysis of past studies employing or developing measures of complexity. The analysis should result in explicitly categorizing paper in terms of the nature of complexity measure.	
3	Show that the proposed generalized complexity measure accommodates extant measures and does indeed provide a generalized framework for measuring complexity.	
Deliverable 1: Joint paper with CSC staff covering Milestones 1-3 to be submitted to relevant conference or a journal (TBD)		

3 References

Bashir, H. A., and Thomson, V. (1999). Metrics for design projects: a review. *Design Studies*, 20(3), 263-277.

Braha, D., and Maimon, O. (1998). The measurement of a design structural and functional complexity. *IEEE Transactions on Systems, Man, and Cybernetics-Part A*, 28(4), 527-535.

Chen, L., and Li, S. (2005). Analysis of decomposability and complexity for design problems in the context of decomposition. *Journal of Mechanical Design*, 127(4), 545-557.

Dierneder, S., and Scheidl, R. (2001). Complexity analysis of systems from a functional and technical viewpoint. R. Moreno-Díaz, B. Buchberger & J. Luis Freire (Eds.), *Computer Aided Systems Theory — EUROCAST 2001* (Vol. 2178, pp. 223-232): Springer Berlin Heidelberg.

Edmonds, B. (1999). *Syntactic measures of complexity*. PhD, University of Manchester, Manchester, UK.

Efatmaneshnik, M., Reidsema, C., Marczyk, J., and Balaei, A. (2010). Immune decomposition and decomposability analysis of complex design problems with a graph theoretic complexity In E. Szczerbicki & N. Nguyen (Eds.), *Measure Smart Information and Knowledge Management* (Vol. 260, pp. 27-52): Springer Berlin / Heidelberg.

Efatmaneshnik, M. and Ryan, M. (2016), A general framework for measuring system complexity, *Complexity*, 21(s1), pp. 533-546.

Kreimeyer, M. and Lindemann U. (2011), *Complexity metrics in engineering design*, Springer.

McCabe, T. (1976). A Complexity Measure. *IEEE Transactions on Software Engineering*, 2(4), 308-320.

Suh, N. P. (2005). *Complexity: theory and applications*. Oxford University Press.

Summers, J. D., and Shah, J. (2003). Developing measures of complexity for engineering design. *International Design Engineering Technical Conference DETC'03*, Chicago, Illinois.

4 Requirements

Please provide:

- A brief CV describing your research background.
- A focused statement of your suitability for undertaking the work detailed above.
- A detailed description outlining how you would undertake the research described above.
- A brief project plan attaching dates and an outline budget to the milestones outlined above.

5 Submissions

Submissions must be lodged via email, as a PDF file, to: capabilitysystems@adfa.edu.au.

Inquiries may be directed to: Associate Professor Mike Ryan, Director, Capability Systems Centre, capabilitysystems@adfa.edu.au.