Consideration of temporal variability to discover ecologically robust reef futures

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Abstract: A key step in decision-making under deep uncertainty (DMDU) is the identification of beneficial and desirable pathways to future states through a process known as scenario discovery. Common approaches to scenario discovery apply a static criterion, i.e., a single aggregate metric such as the mean performance, to compare scenario outcomes. Scenarios are typically considered of interest if said performance metric is maximised or above a given threshold. A known issue is the lack of consideration such an approach has for the behaviour of a given system over time is effectively ignored (Steinmann et al. 2020). Use of meta-metrics – metrics which assess metrics – offers one approach to resolving this limitation.

We introduce the V meta-metric to allow further consideration of the temporal variability in assessing scenario outcomes. The meta-metric produces what we refer to as the V score indicating the mean of the median performance as well as the level of variability of the given performance measure over time. Indication of variability is provided by the Gini Mean Difference (GMD), such that the V meta-metric is formulated as:

$$V(x) = \text{mean}\big(\text{median}(x),\ 1 - GMD(x)\big),$$

where x is the normalized scenario trajectory (i.e., a time series) of system state as indicated by a given measure, such as coral cover or other, and GMD is calculated with:

$$GMD(x) = \frac{2}{n(n-1)}\sum_{i=1}^{n}(2i - n - 1)x_{(i)}$$

As the base performance measure (x) is normalised, the complement of GMD (i.e., $1 - GMD(x)$) will produce a value $\in [0, 1]$, where lower values indicate a higher level of diversity in the time series, and higher values implies greater consistency and thus stability. The V score is then also bound between 0 and 1, making it accessible for use with common optimisation approaches. An assumption is that the stability of the given performance measure (x) is a desirable scenario property. Robustness of scenario trajectories indicated by a range of performance metrics, such as coral cover and available shelter volume among others, can then be assessed. Examples with the Adaptive Dynamic Reef Intervention Algorithms (ADRIA) decision support platform for exploring reef futures will be presented (https://zenodo.org/record/7879785). An aim of ADRIA is to inform and assess deployment of considered interventions across the Great Barrier Reef in the face of future uncertainty. Opportunities for further improvements to the meta-metric will also be discussed.

REFERENCES

Steinmann, P., Auping, W.L., Kwakkel, J.H. 2020. Behavior-based scenario discovery using time series clustering. Technological Forecasting and Social Change, 156, 120052. https://doi.org/10.1016/j.techfore.2020.120052

Keywords: *Meta-metrics, decision support, scenario discovery, reef futures*