25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

Building trust in hazard model uncertainties

Carolyn Huston [a], Petra Kuhnert [a], Andrew Bolt [a] and Jennifer Davis [b]

[a] CSIRO Data61; [b] College of Arts and Social Sciences, The Australian National University
Email: Carolyn.Huston@csiro.au

Abstract: Modelling and simulation tools such as Spark (Miller et al. 2015) and Phoenix Rapidfire (Tolhurst et al. 2012) underpin many decisions taken in the hazards domain in both planning and reactive contexts. One element of the decision-making process is trust, enabling decision makers to feel empowered to make decisions based on models of complex systems, such as the fires represented in wildfire simulators. There is a long history of using mathematical and computational tools to support understanding of bushfire hazards including conditions associated with high fire spread; to rates-of-spread in different vegetations and landscapes; to the tools used to communicate fire risks (Rothermel 1972). Existing solvers such as the previously noted Spark and Phoenix Rapidfire tend to focus on single fire perimeter outputs, where sometimes sets of conditions might be reported on to reflect on more than one possible fire outcome due to uncertain conditions. Conceptualizing and reporting on uncertainty is not built-in to these modeling systems beyond being able to be run through such multiple parameterizations.

We discuss a fire emulator (using a neural net architecture) that is hybrid in approach Bolt et al. 2022). It is developed using Spark modeled fire perimeter inputs, having further hybrid data informing necessary spatial and temporal environmental inputs (weather, topography, vegetation and similar). We note that there can be considerable uncertainty in these input values, both in terms of correctness, but also in terms of resolution. Our method natively incorporates aspects of uncertainty particularly input uncertainty into fire spread reporting. The training data is based on typical Spark inputswith a focus on windspeed and direction uncertainty. An advantage of the emulator is that, once training is complete, for every set of fire simulation inputs it creates a probabilistic output and does not require the development of ensembles of Spark runs.

We introduce the idea of a design framework that can be used to explore some of the affordances of such emulators, focusing on how the structure of the emulator affords trust (Davis 2020). Particular opportunities and constraints of the emulator are discussed with a mechanisms and conditions framework where the emulator might *request, demand, encourage, discourage, refuse,* or *allow* certain outcomes and understandings.

There are challenges to building trust in the system, as the emulator encodes information about scientific and physical understanding of fire spread in a fundamentally different way to typical fire characteristic solvers. We use the relationship to Spark as a pathway to enhancing understanding and trust in the emulator. We provide both a toy example of uncertain fire propagation outputs to explore affordances given by more native reporting of uncertainty, and how using the affordance language framework can support users of the technology to understand, accept and explore fire spread models reported with such uncertainty.

We hope that exploring this new emulator approach using the language of affordances enables discussion about many of the tricky aspects of decisions related to fire in different contexts, and how humans interact with each other and technology in such circumstances.

REFERENCES

Bolt, A., Huston, C., Kuhnert, P., Dabrowski, J.J., Hilton, J., Sanderson, C. 2022. A spatio-temporal network forecasting approach for emulation of fire-front models. 2022 Signal Process: Algorithms, Architectures, Arrangements, and Applications. IEEE. 110-115.

Dabrowski, J.J., Pagendam, D.E., Hilton, J., Sanderson, C., MacKinlay, D., Huston, C., Bolt, A., Kuhnert, P. 2023. Bayesian physics informed neural networks for data assimilation and spatio-temporal modelling of wildfires. Spatial Statistics, 100746.

Davis, J. 2020. How artifacts afford: The power and politics of everyday things. MIT Press.

Miller, C., Hilton, J., Sullivan, A., and Prakash, M. 2015. SPARK – A Bushfire Spread Prediction Tool. Environmental Software Systems. Infrastructures, Services and Applications. Eds. Denzer, R, Argent, R.M., Schimak, G., Hřebíček, J. Springer International Publishing, pp. 262-271.

Rothermel, R.C., 1972, A mathematical model for predicting fire spread in wildland fuels. Res. Pap. INT-115. Ogden, UT: US Department of Agriculture, Intermountain Forest and Range Experiment Station.

Tolhurst, K. Duff, T., and Chong, D. 2012. PHOENIX Rapidfire: Under the Hood. Unpublished Guide.

Keywords: *Emulator, neural net, affordance, trust*