The Journal of Open Source Education

Nashpy: A Python library for the computation of Nash equilibria

Vincent Knight[1] **and James Campbell**[1]

1 Cardiff University, School of Mathematics, UK

DOI: 10.21105/jose.00018

Software

- Review
- Repository
- Archive

Submitted: 25 June 2018
Published: 25 June 2018

Summary

Game theory is the study of strategic interactions where the outcomes of choice depend on the choices of all participants. A key solution concept in the field is that of Nash Equilibrium (Nash and others 1950). This solution concept corresponds to a coordinate at which no participant has any incentive to change their choice. Some applications of this concept include the modelling of healthcare decisions (Vincent Knight, Komenda, and Griffiths 2017) as well as evolutionary game theory. A number of algorithms exist to compute this Nash equilibria, for example the Lemke-Howson algorithm (Lemke and Howson 1964).

The state of the art in terms of software implementations of these algorithms is **Gambit** (McKelvey, McLennan, and Turocy 2006). Gambit includes a python wrapper to its core C functionality however is not currently portable (for example Windows is not supported).

`Nashpy` is a Python library with all dependencies being part of the standard scientific Python stack (numpy and scipy (Jones et al. 2001–2001--)) thus it is portable. Nashpy currently implements 3 algorithms for the computation of equilibria (currently only for 2 player games) and is extensively documented, including theoretic reference material on the algorithms: nashpy.readthedocs.io. This documentation coupled with the readability of Python make it a particularly effective teaching tool as students can inspect the code to reinforce their understanding of the algorithms. Furthermore, the software is automatically tested using a combination of unit, integration and property based tests with 100% coverage. All the documentation is doctested and in fact the example in this paper is as well.

An often used game in beginner game theory classes is referred to as the *battle of the sexes* and here is an example of how to use `Nashpy` to obtain the equilibria:

```
>>> import nashpy as nash
>>> import numpy as np
>>> A = np.array([[2, 0], [0, 1]])
>>> B = np.array([[1, 0], [0, 2]])
>>> game = nash.Game(A, B)
>>> for eq in game.support_enumeration():
...     print(eq)
(array([ 1.,  0.]), array([ 1.,  0.]))
(array([ 0.,  1.]), array([ 0.,  1.]))
(array([ 0.666...,  0.333...]), array([ 0.333...,  0.666...]))
```

`Nashpy` is designed to be used by researchers and students in courses in the fields of mathematics, computer science and/or economics. It is already currently being used in

a final year course at Cardiff University. `Nashpy` has been archived to Zenodo with the linkd DOI: (Vince Knight and Baldevia 2018).

“‘

Acknowledgements

We acknowledge code contributions from Ria Baldevia as well as many helpful discussions with Nikoleta Glynatsi.

References

Jones, Eric, Travis Oliphant, Pearu Peterson, and others. 2001–2001--. “SciPy: Open Source Scientific Tools for Python.” http://www.scipy.org/.

Knight, Vince, and Ria Baldevia. 2018. “Drvinceknight/Nashpy: V0.0.13.” https://doi.org/10.5281/zenodo.1163694.

Knight, Vincent, Izabela Komenda, and Jeff Griffiths. 2017. “Measuring the Price of Anarchy in Critical Care Unit Interactions.” *Journal of the Operational Research Society* 68 (6). Springer:630–42.

Lemke, Carlton E, and Joseph T Howson Jr. 1964. “Equilibrium Points of Bimatrix Games.” *Journal of the Society for Industrial and Applied Mathematics* 12 (2). SIAM:413–23.

McKelvey, Richard D, Andrew M McLennan, and Theodore L Turocy. 2006. “Gambit: Software Tools for Game Theory.” Version 0.2006. 01.20.

Nash, John F, and others. 1950. “Equilibrium Points in N-Person Games.” *Proceedings of the National Academy of Sciences* 36 (1). USA:48–49.