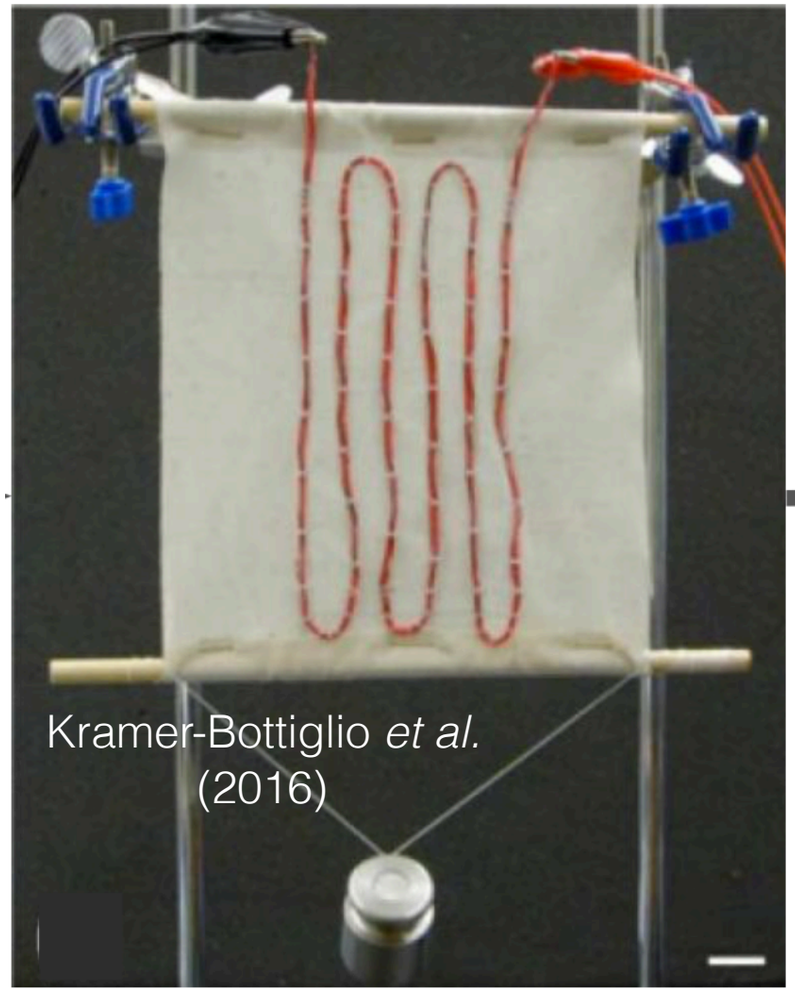
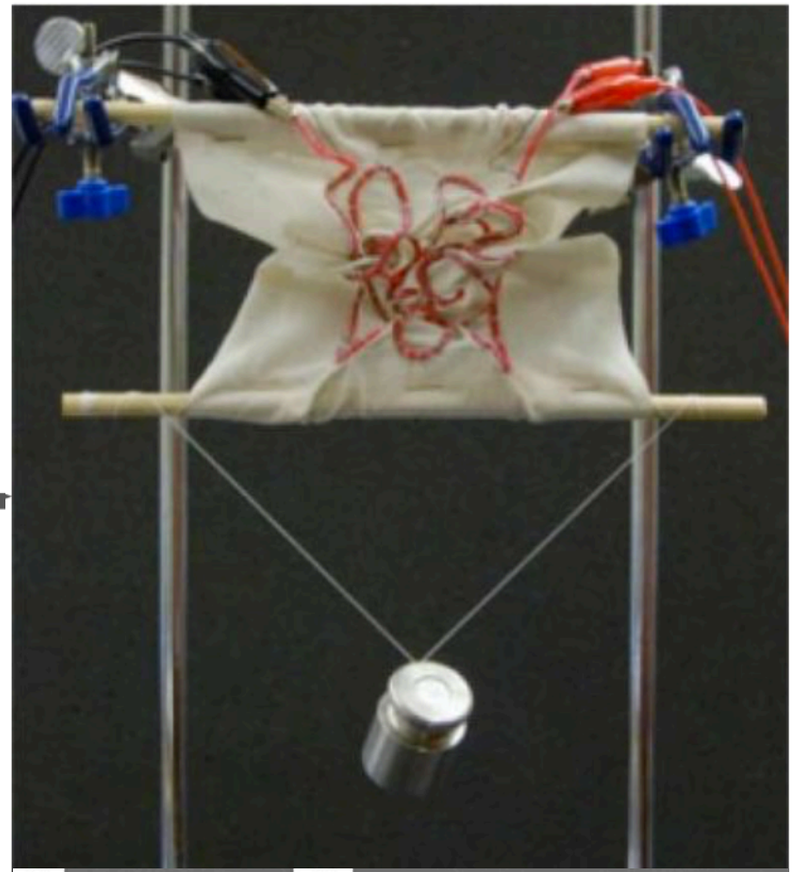
Soft robots that evolve and develop.

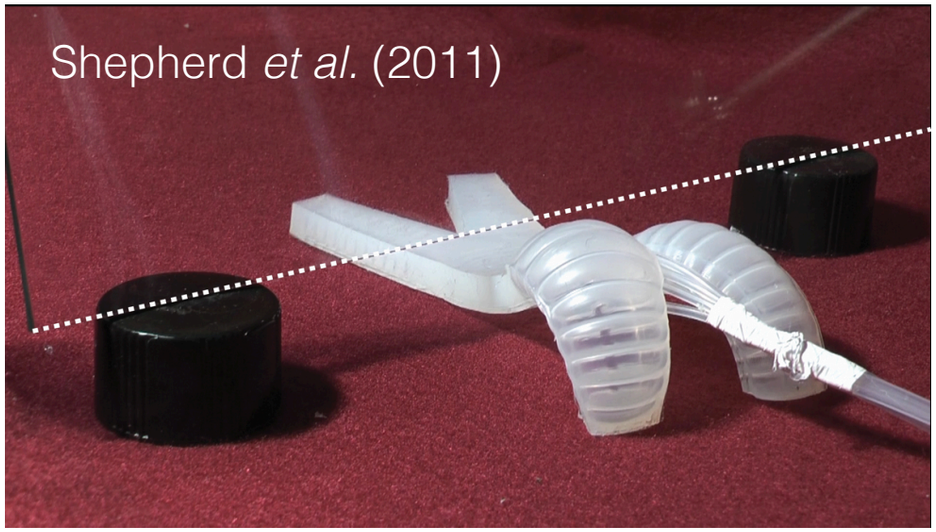
Josh Bongard
Morphology, Evolution & Cognition Laboratory
Vermont Complex Systems Center
University of Vermont



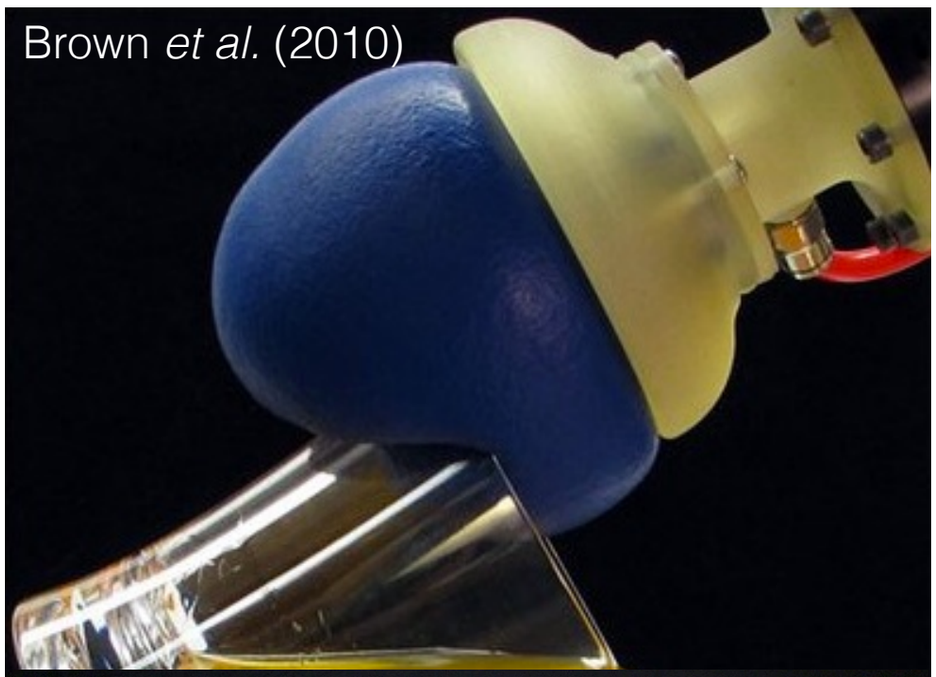
Kramer-Bottiglio *et al.* (2016)



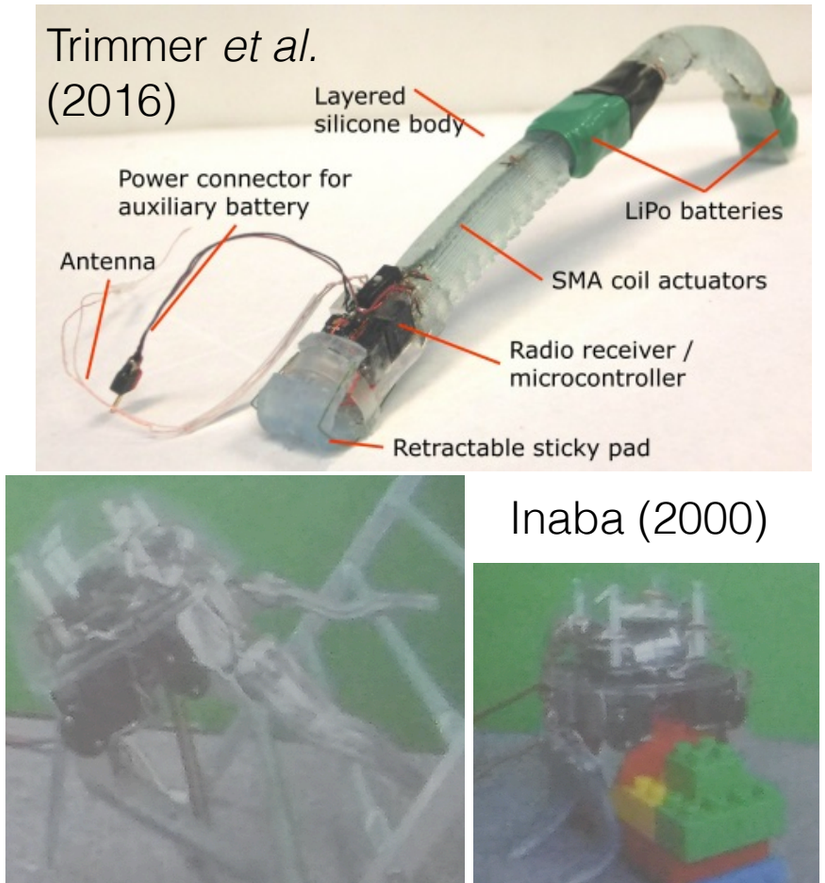
Shepherd *et al.* (2016)



Shepherd *et al.* (2011)

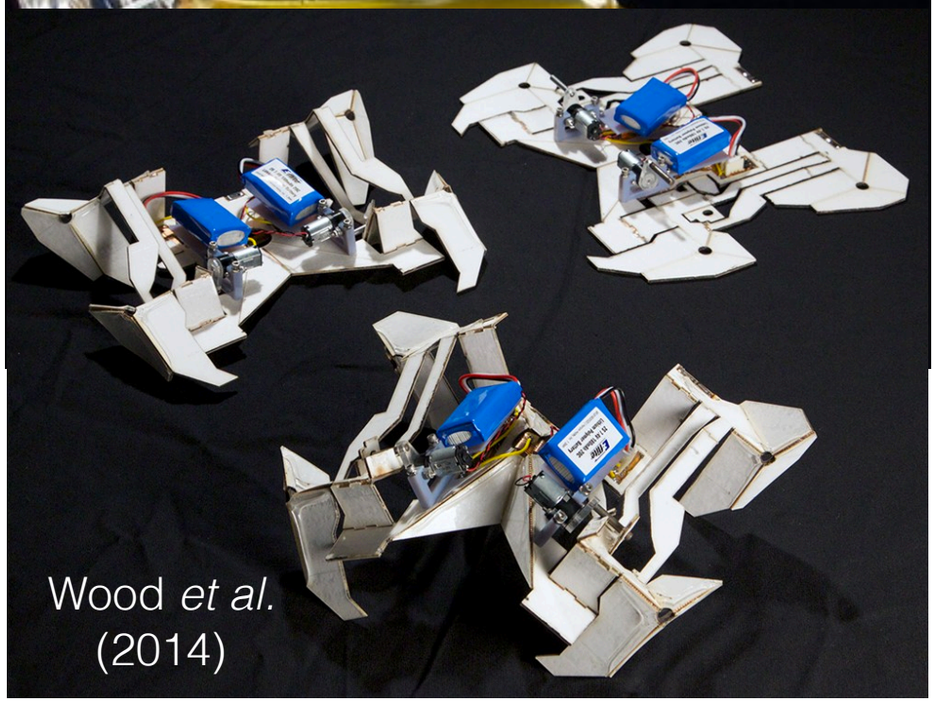


Brown *et al.* (2010)



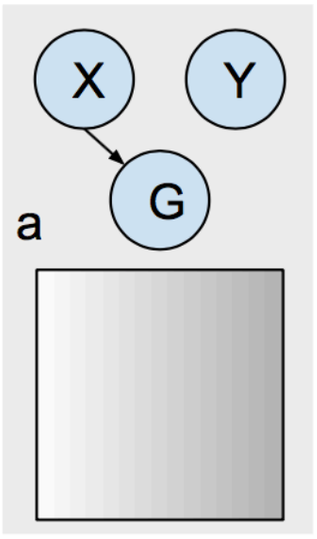
Trimmer *et al.* (2016)

Inaba (2000)



Wood *et al.* (2014)

Cheney, MacCurdy, Clune, & Lipson. 2013. *Procs. of GECCO Conf.*

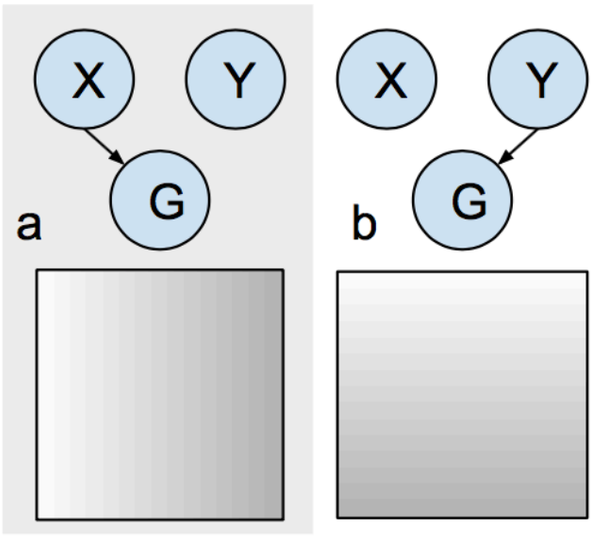


Stanley (2007).

Compositional pattern producing networks:

A novel abstraction of development.

Procs. of the GECCO Conf.



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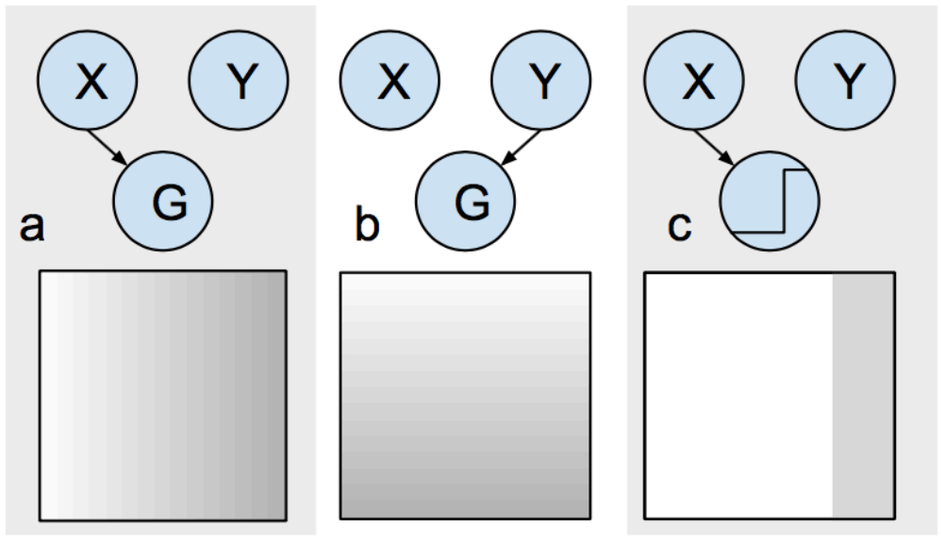

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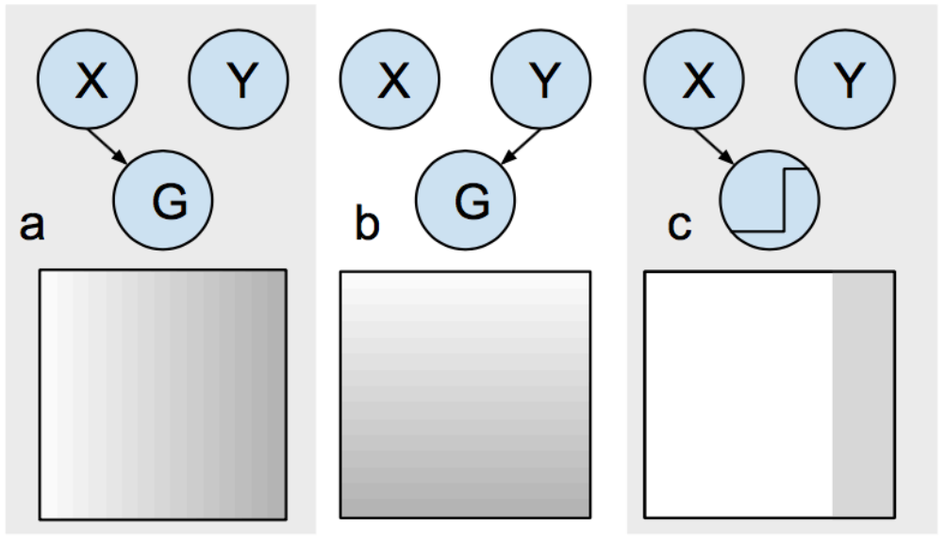

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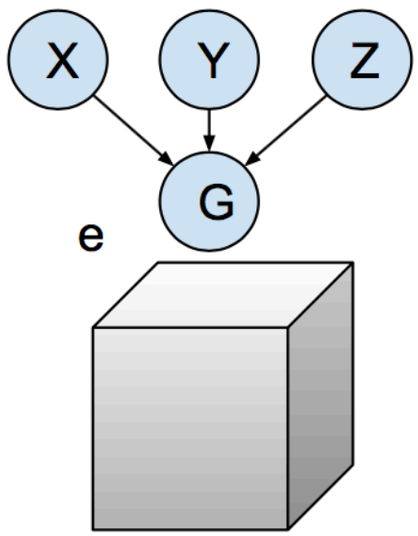

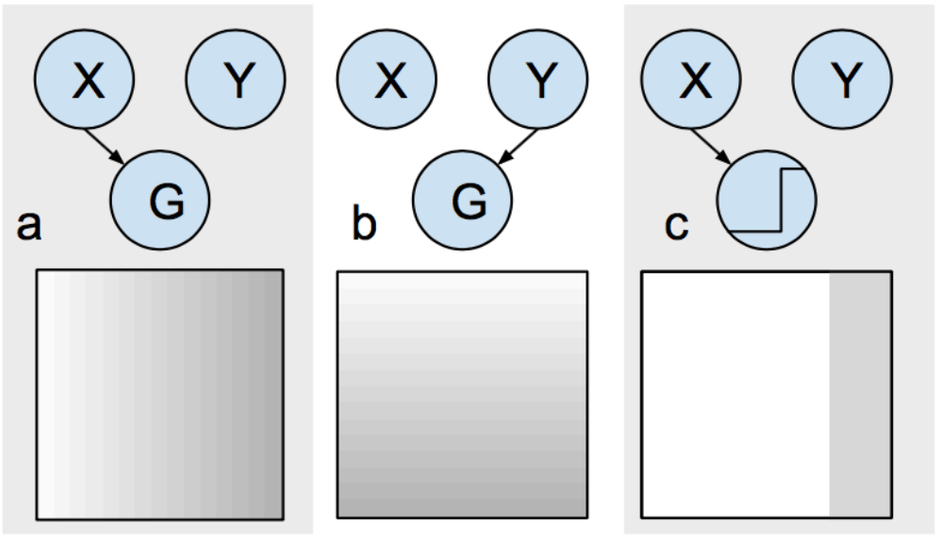

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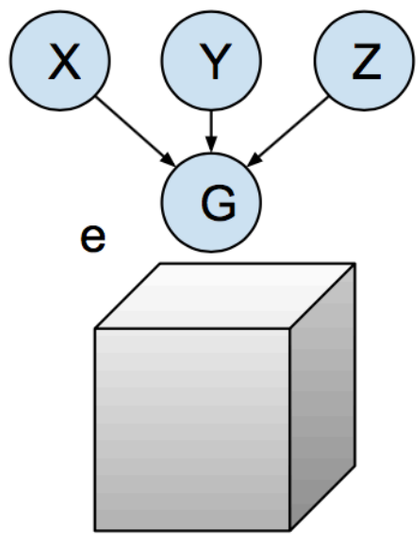
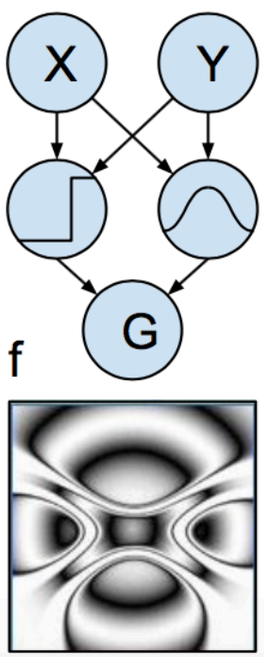
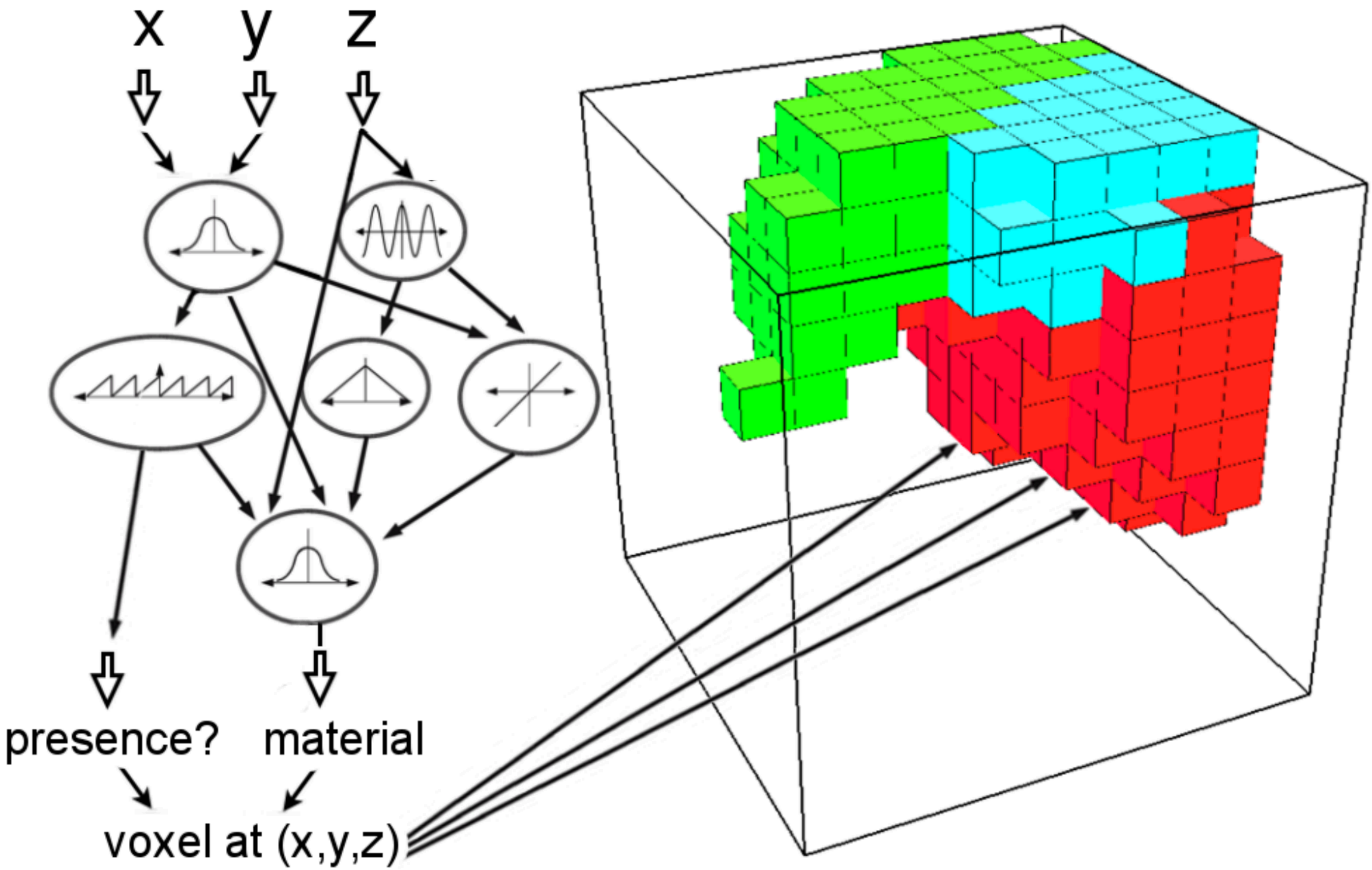
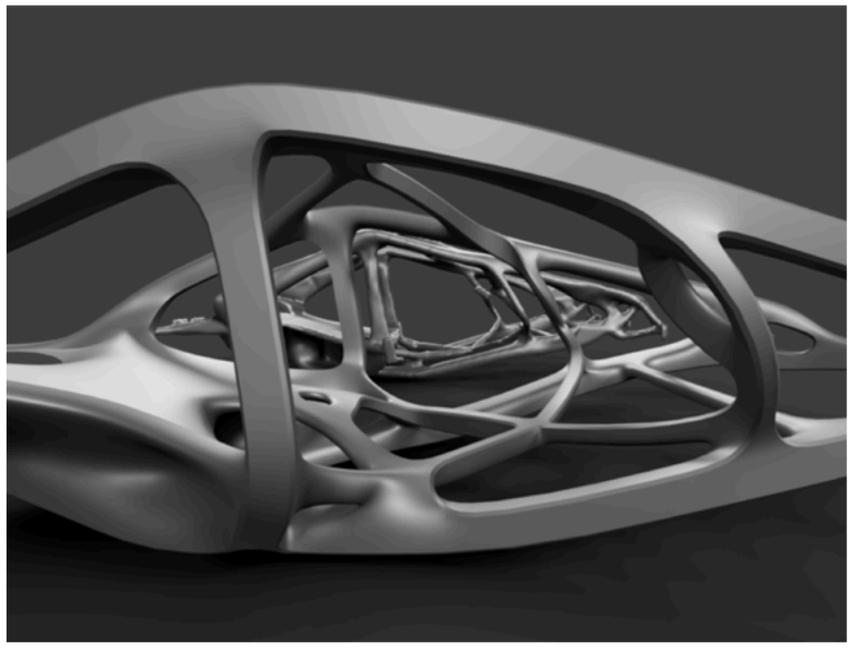




Cheney, MacCurdy, Clune, & Lipson. (2013). *Procs. of GECCO Conf.*



Project Dreamcatcher

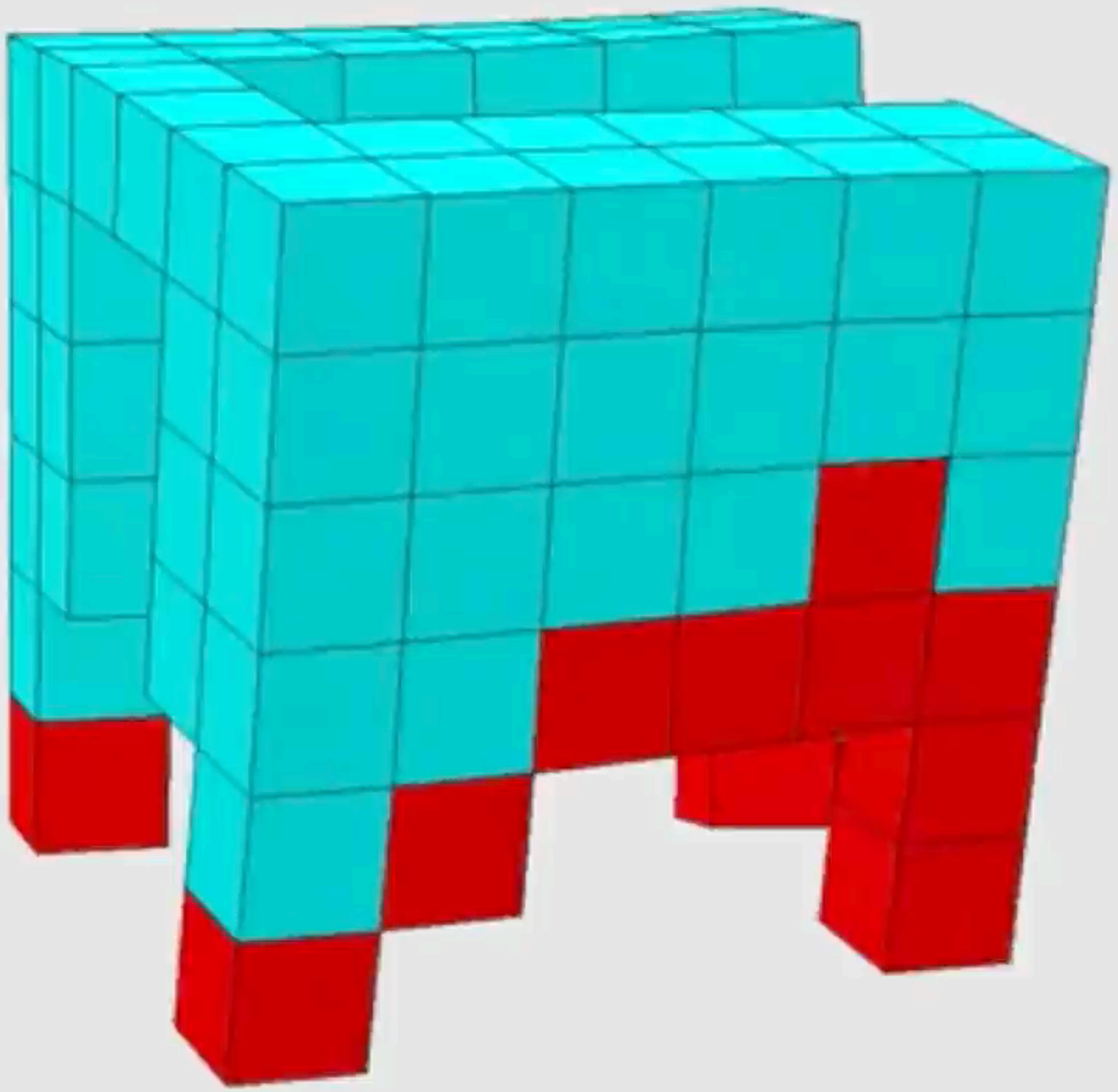


What if a CAD system could generate thousands of design options that all meet your specified goals? It's no longer what if: it's Project Dreamcatcher, the next generation of CAD. Dreamcatcher is a generative design system that enables designers to craft a definition of their design problem through goals and constraints. This information is used to synthesize alternative design solutions that meet the objectives. Designers are able to explore trade-offs between many alternative approaches and select design solutions for manufacture.

GROUPS

Design Research, Computational Science Research

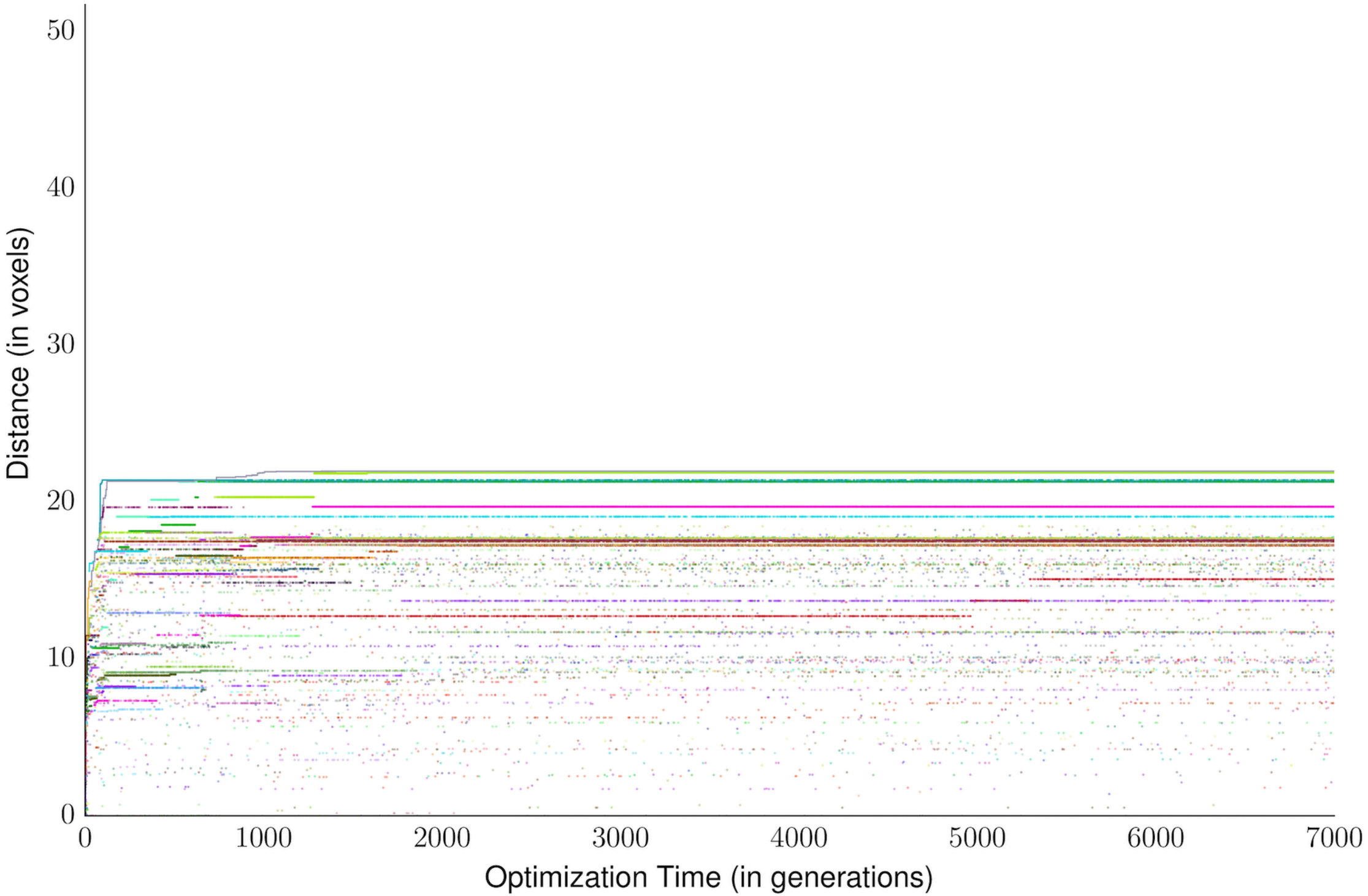
Corucci,
et al. (2017)
Soft
Robotics.
In review.



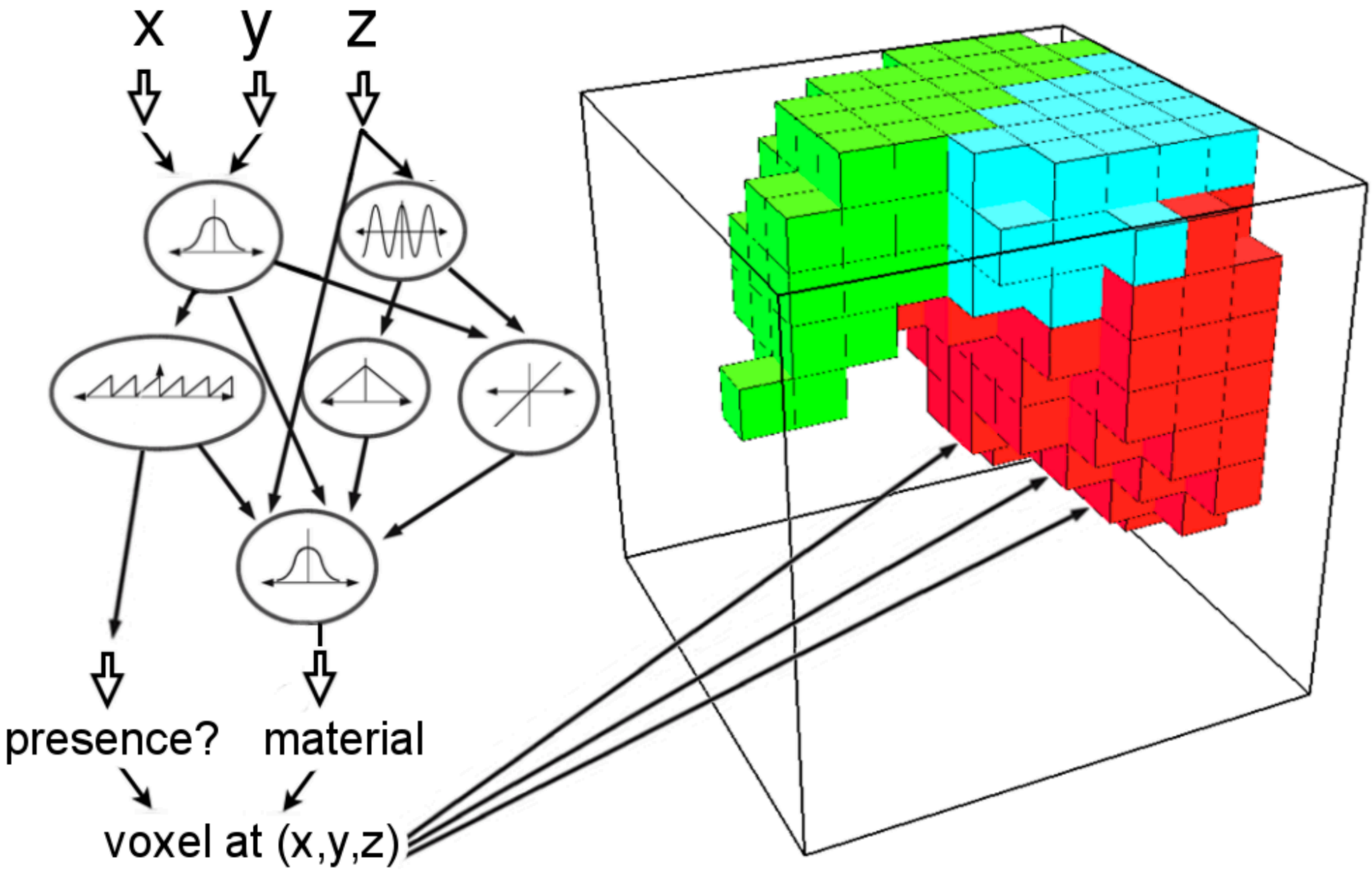
Cheney, Bongard, SunSpiral & Lipson

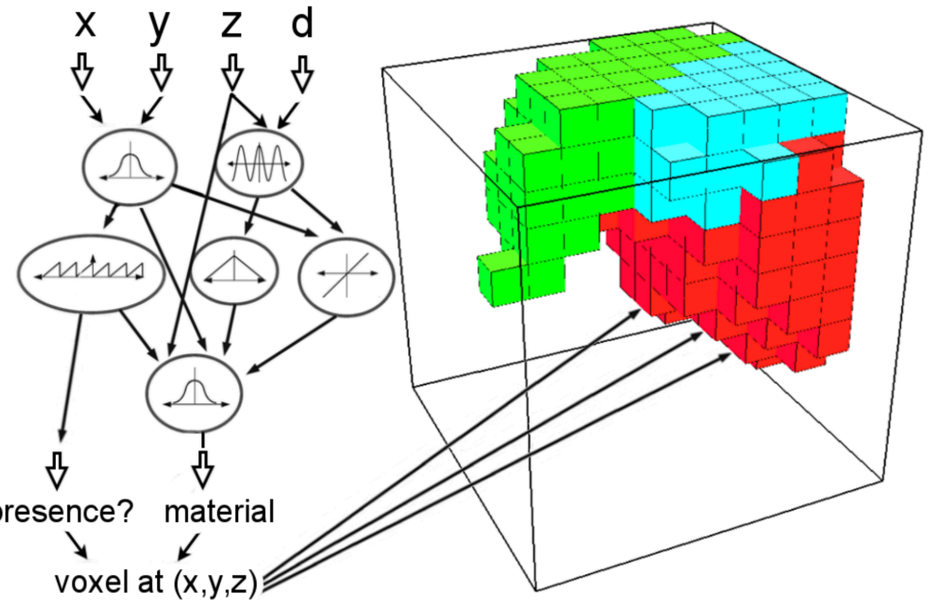
(2017)

arXiv.



Cheney, MacCurdy, Clune, & Lipson. (2013). *Procs. of GECCO Conf.*





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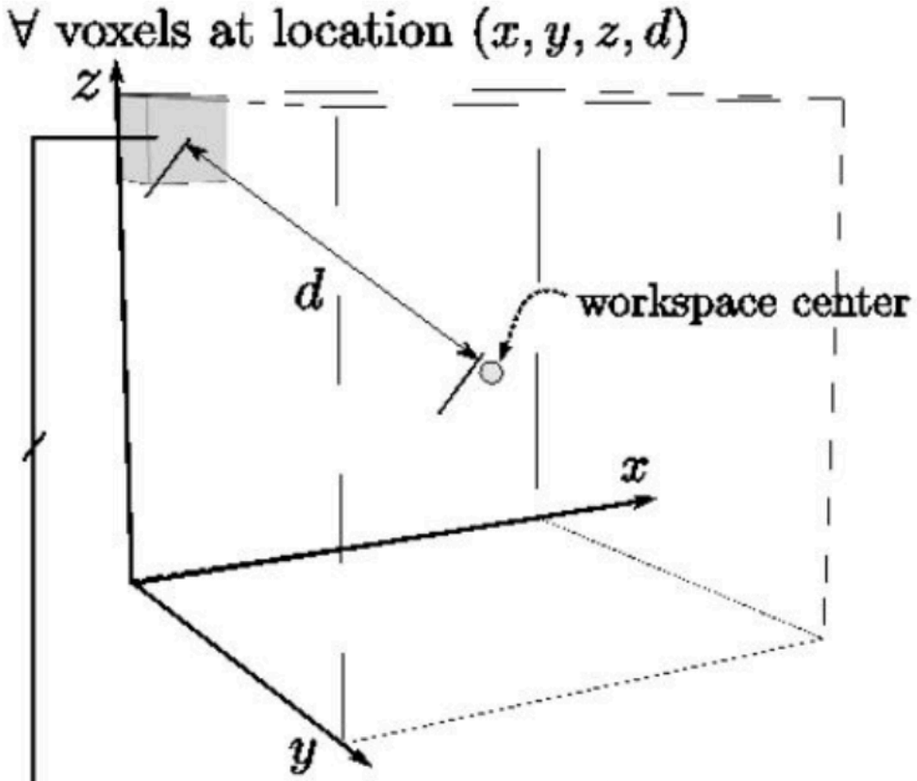
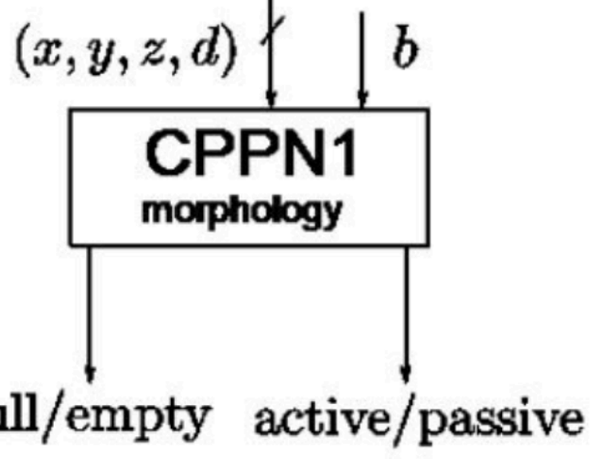


Cheney, Bongard, SunSpiral & Lipson

(2017)

arXiv.

i



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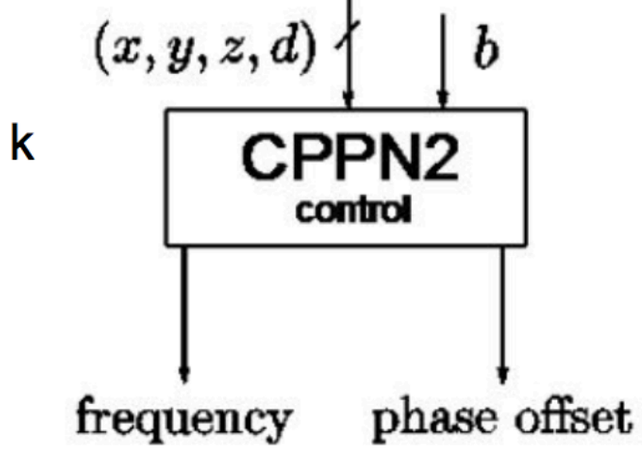

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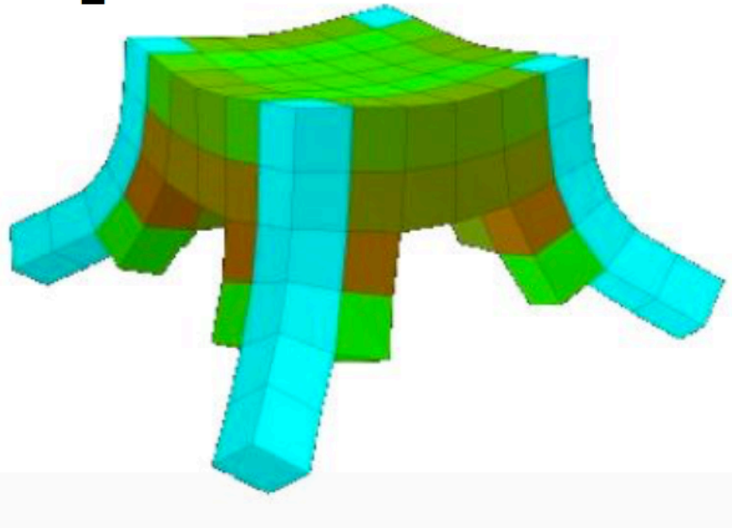
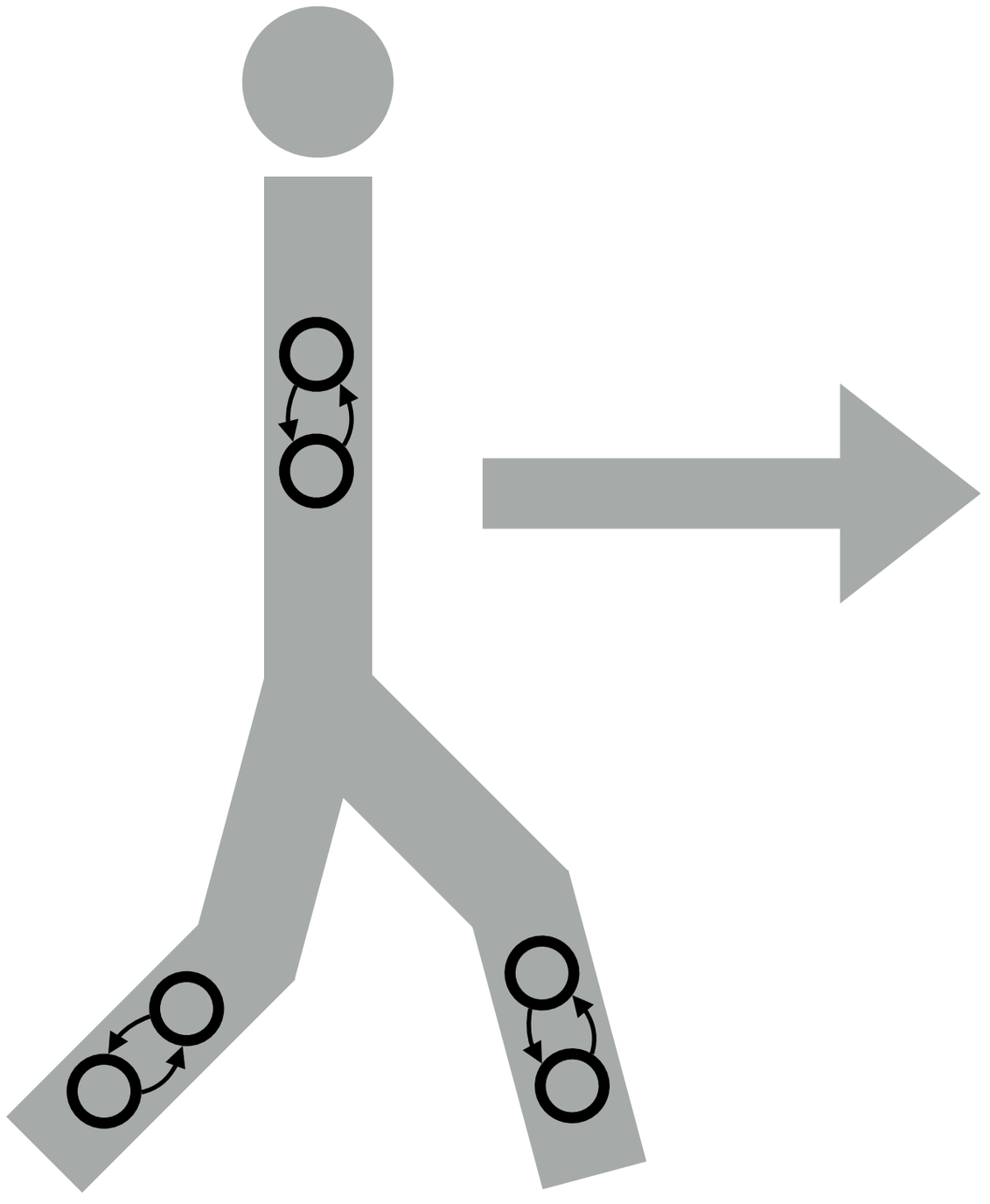


Protecting morphological innovations.

Cheney, Bongard, SunSpiral & Lipson

(2017)

arXiv.



Protecting morphological innovations.

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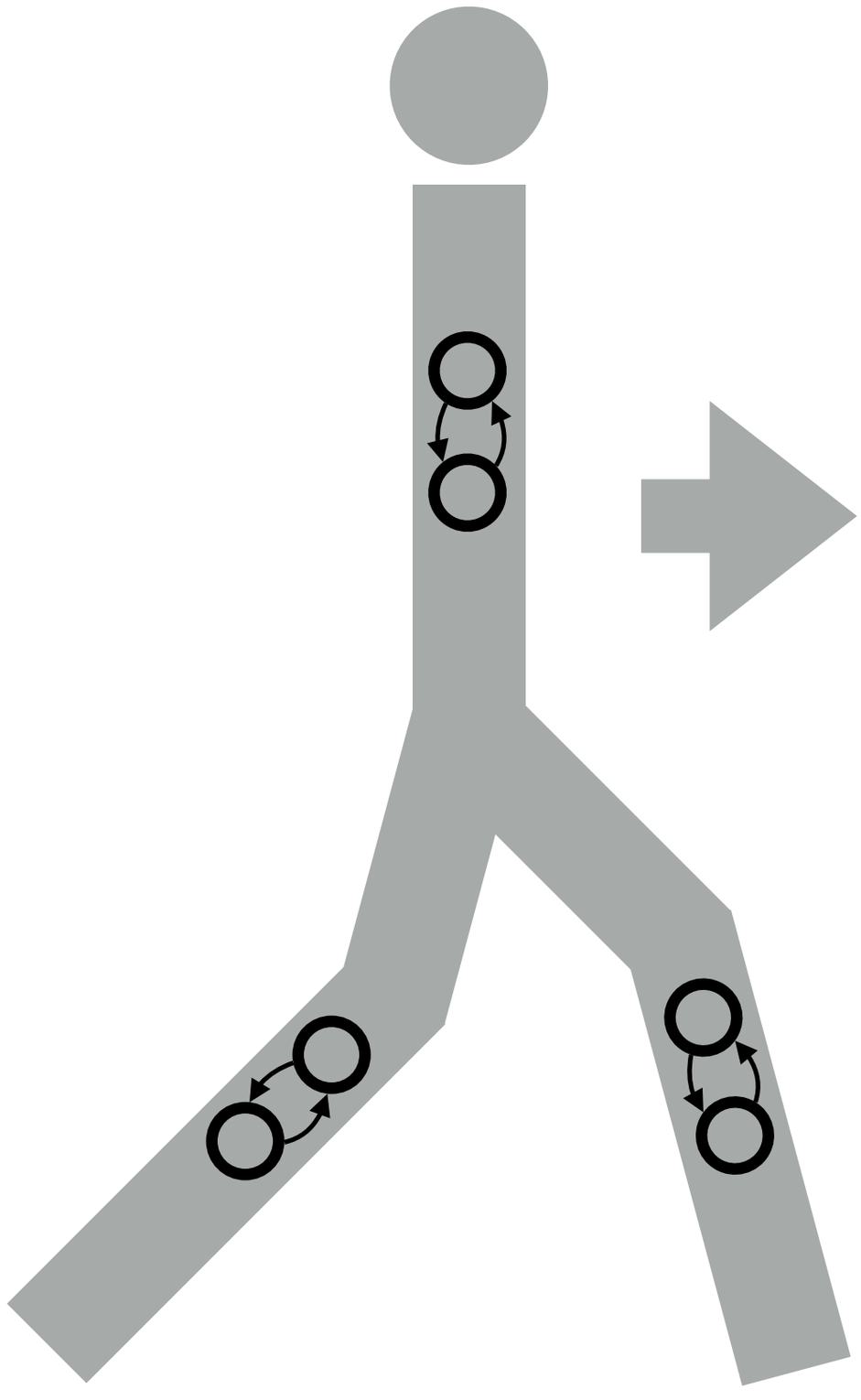
arXiv.



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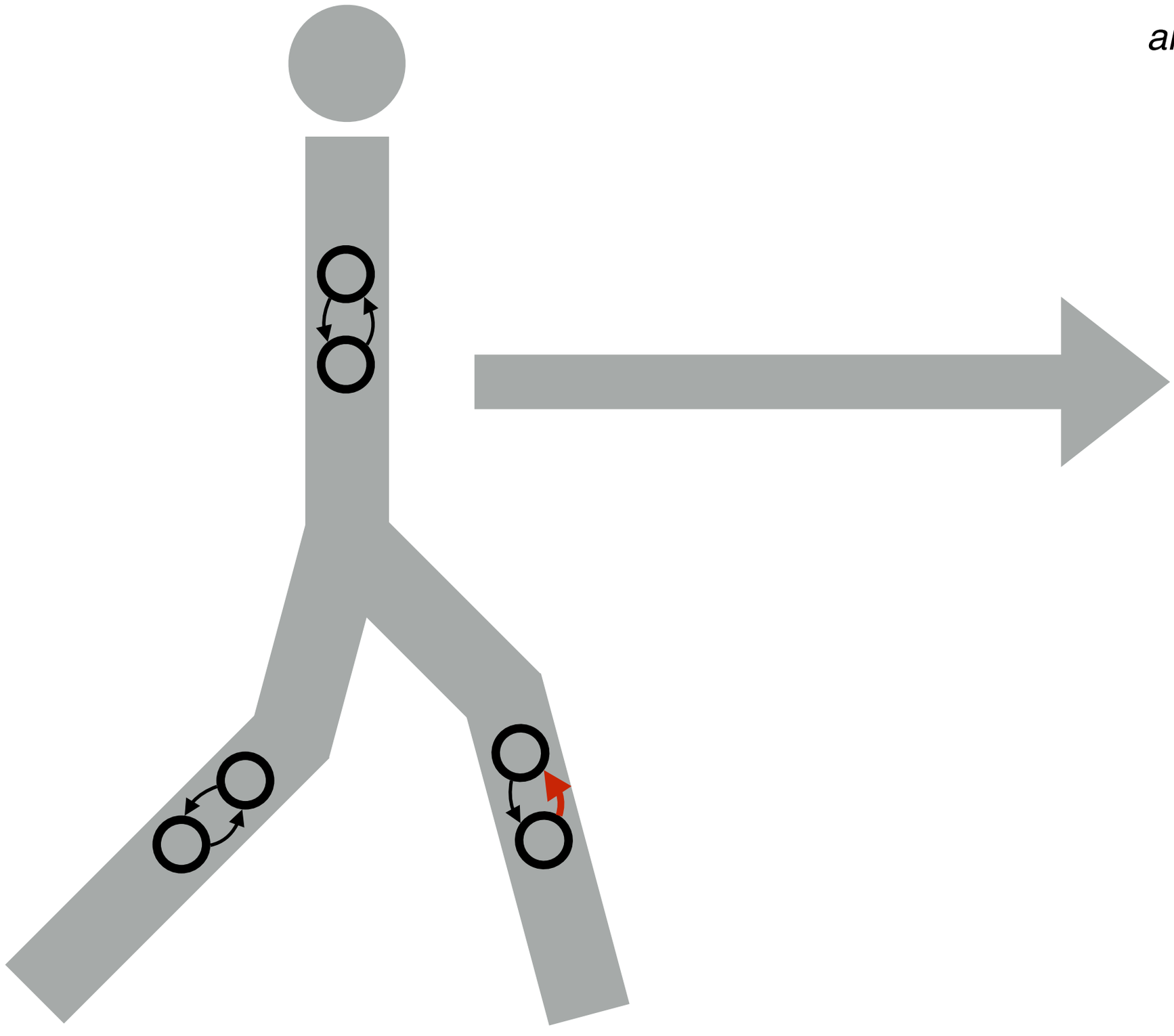

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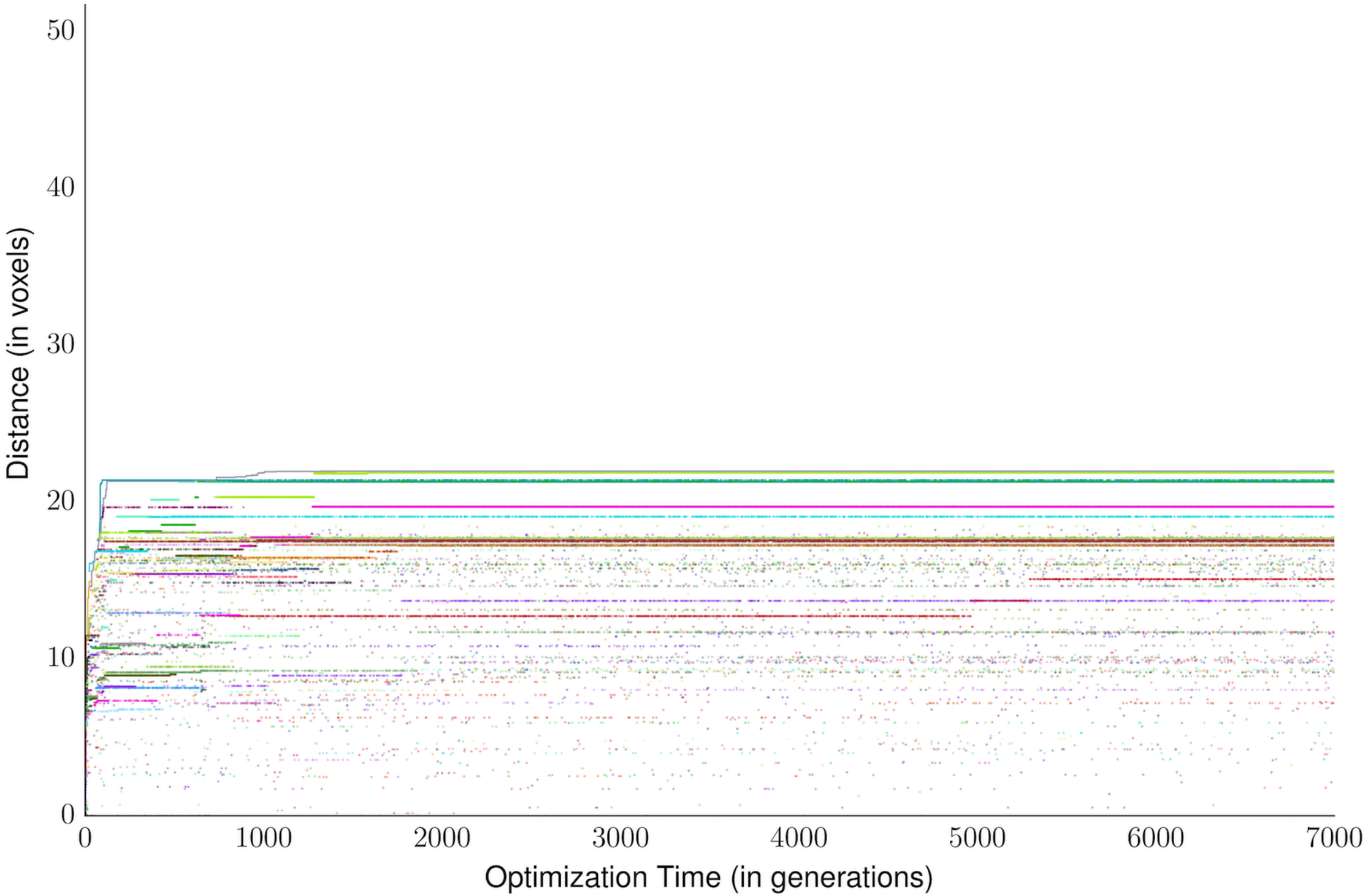

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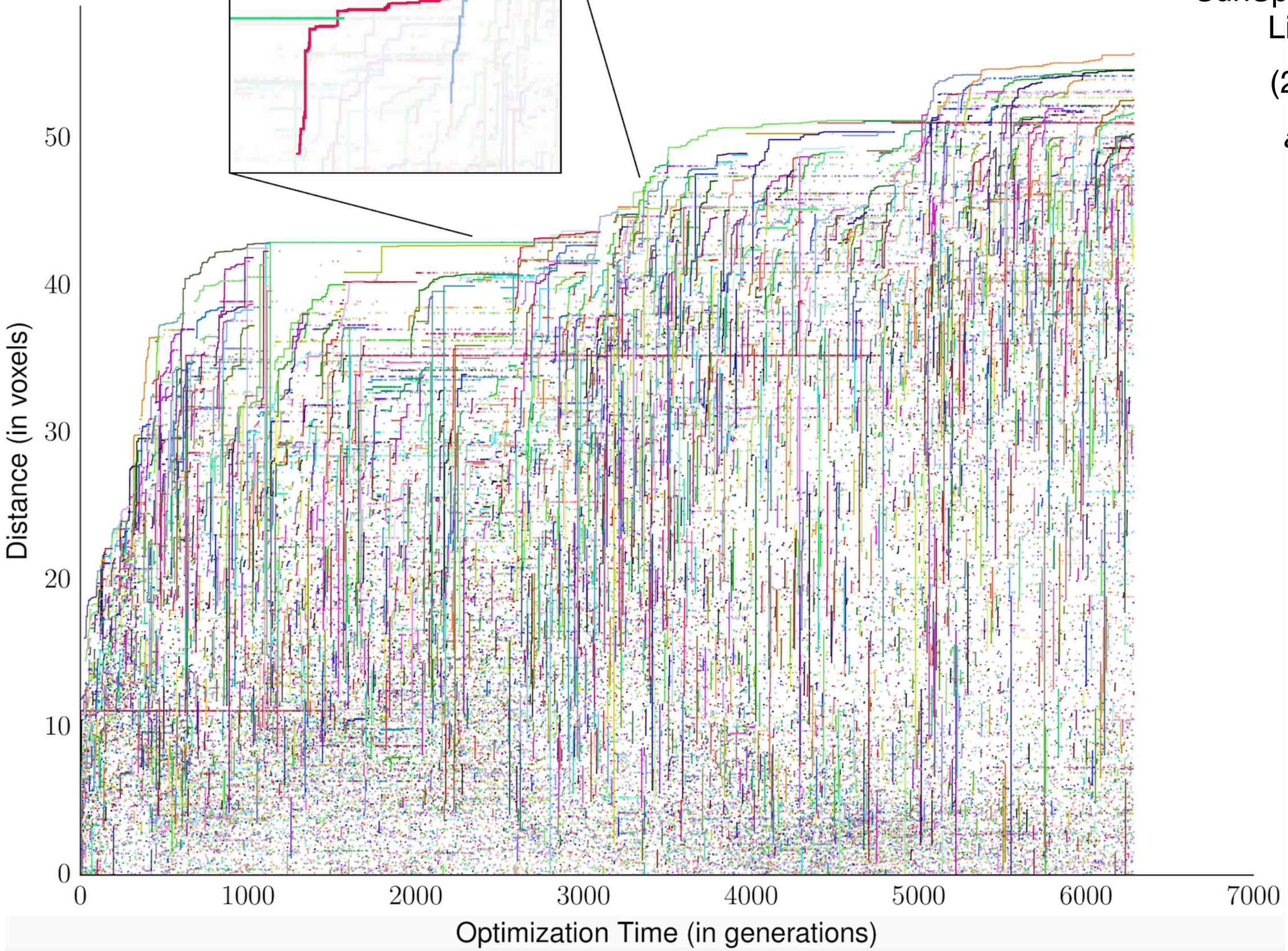
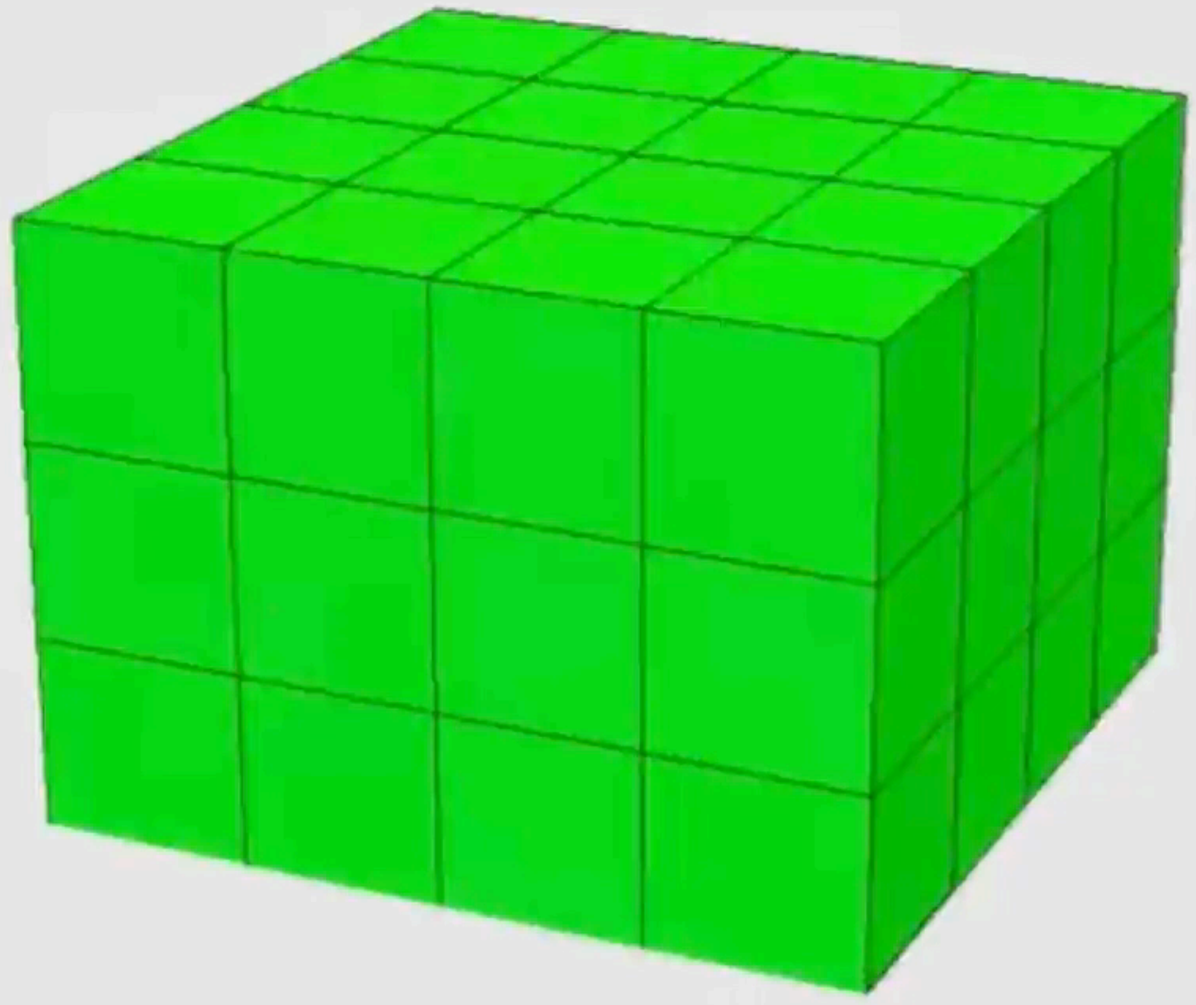
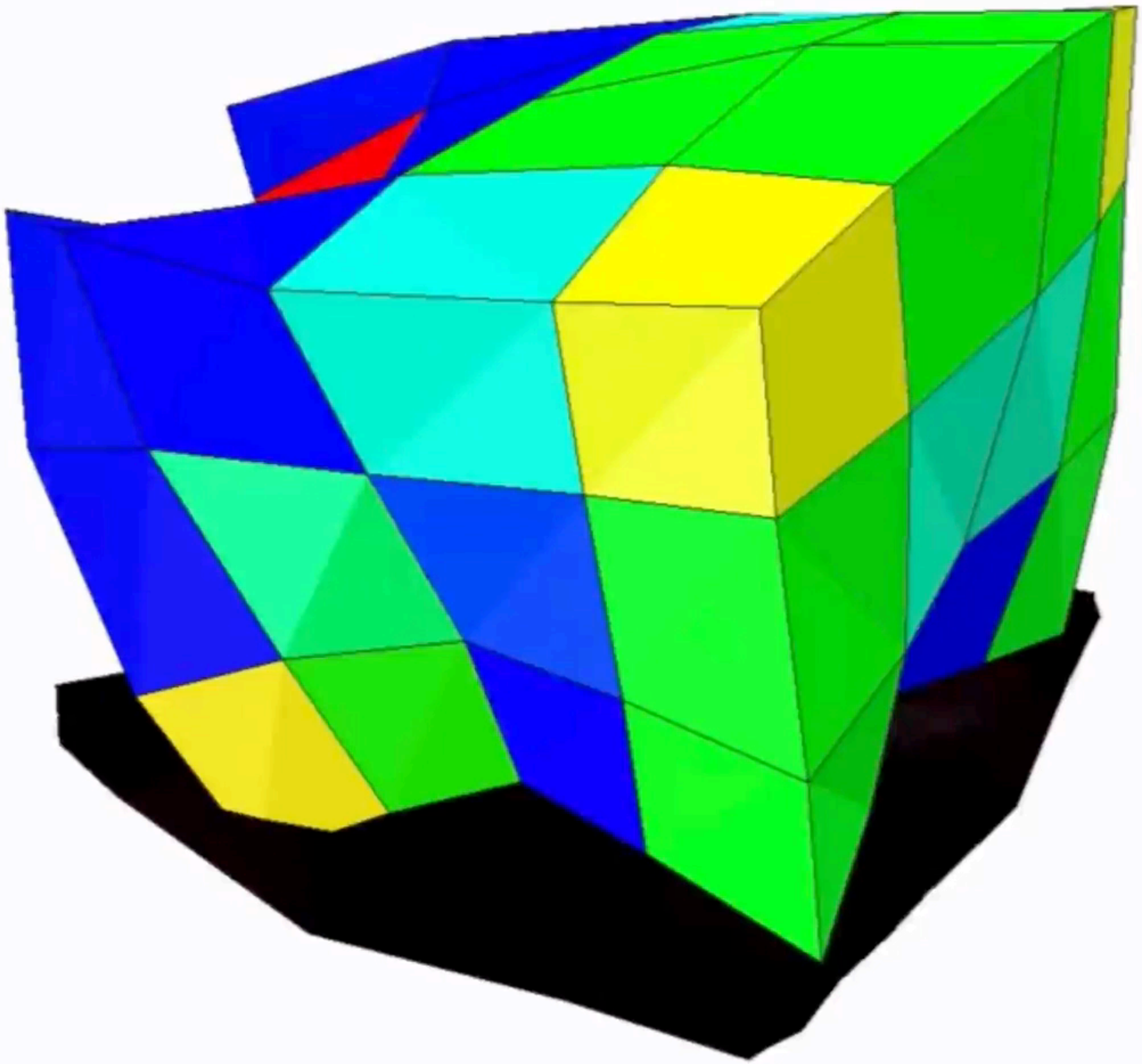




Kriegman et. al. 2017. A Minimal Developmental Model Can Increase Evolvability in Soft Robots. In *Proceedings of GECCO '17.*



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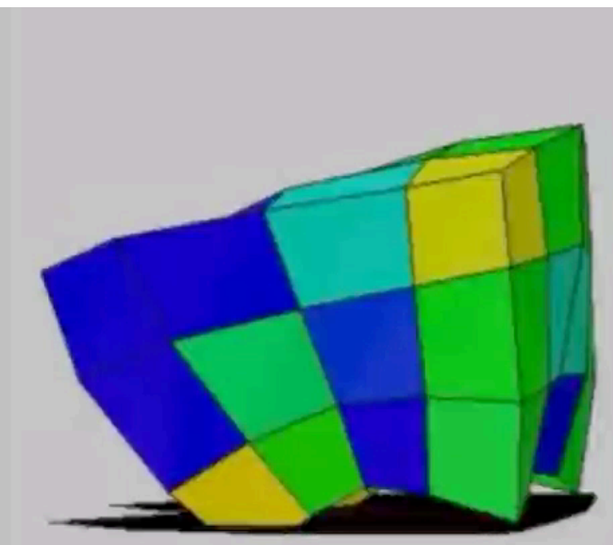
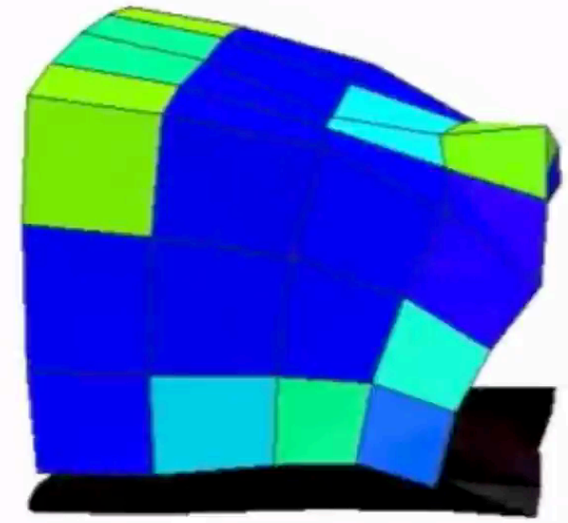
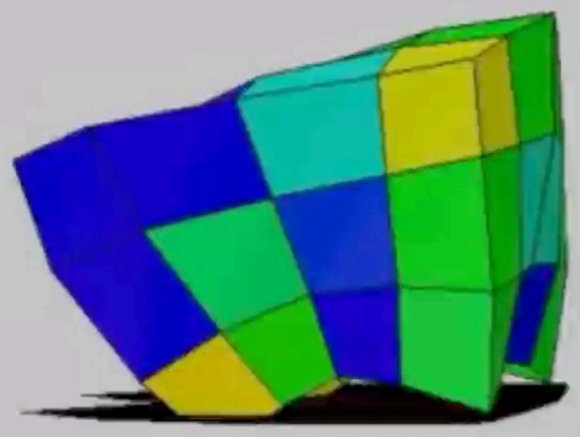
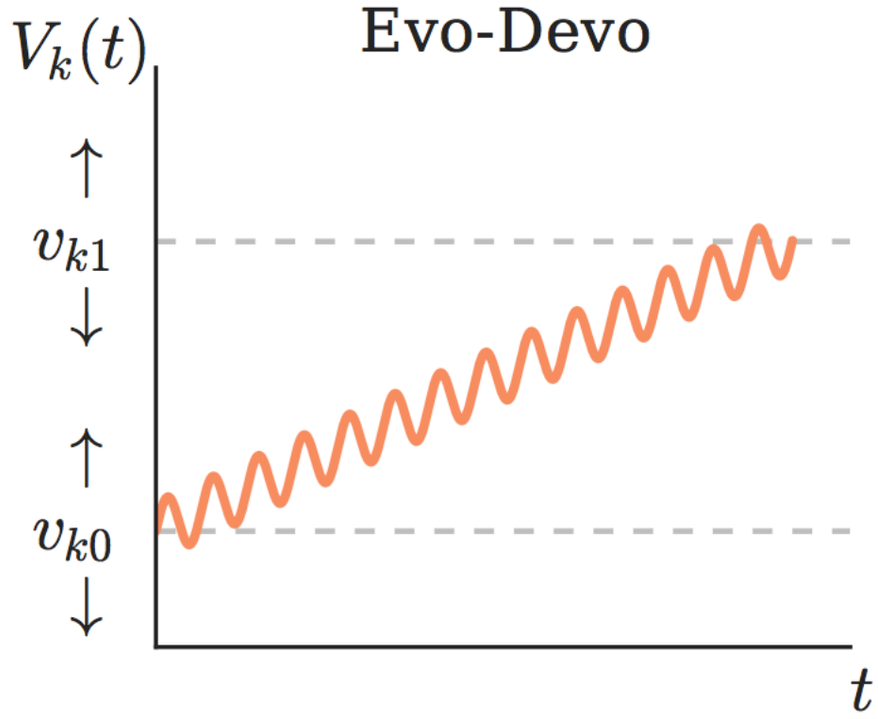






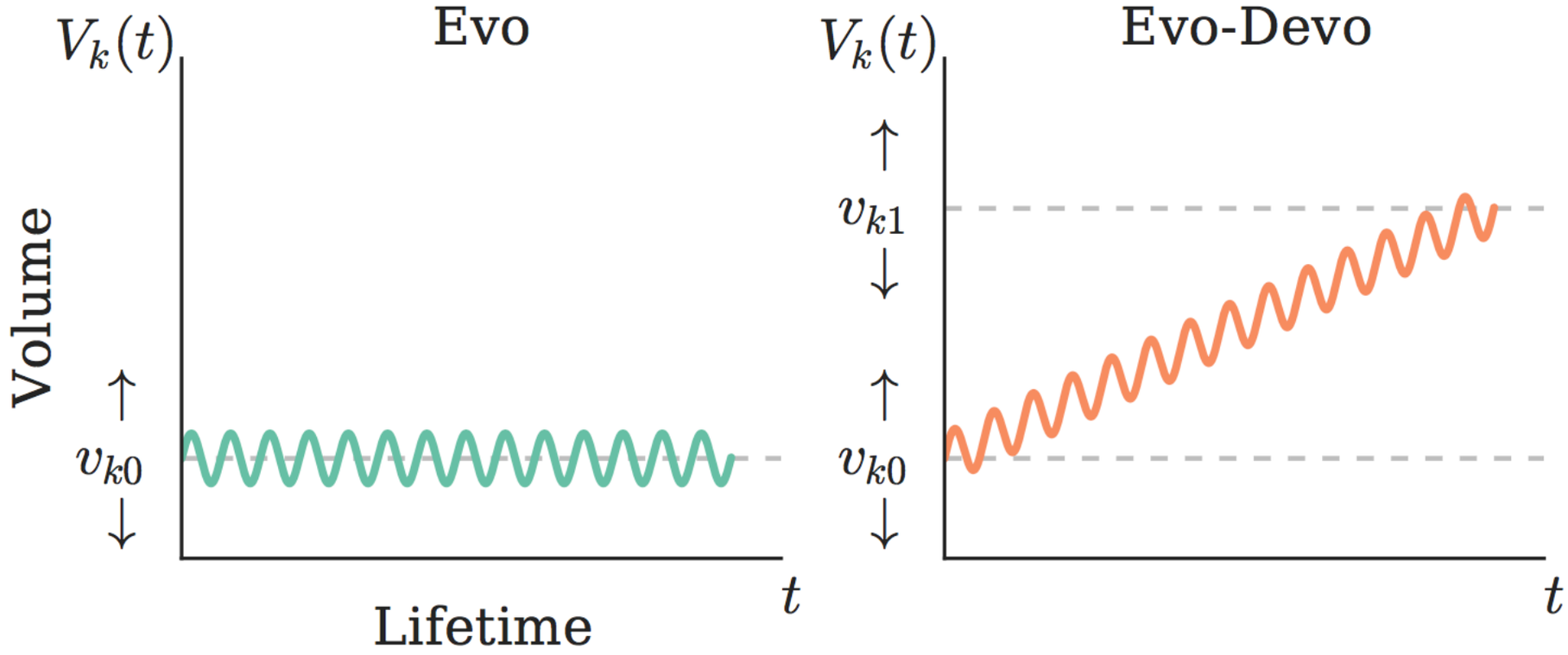
4x4x3 x2 = 96
evolvable parameters



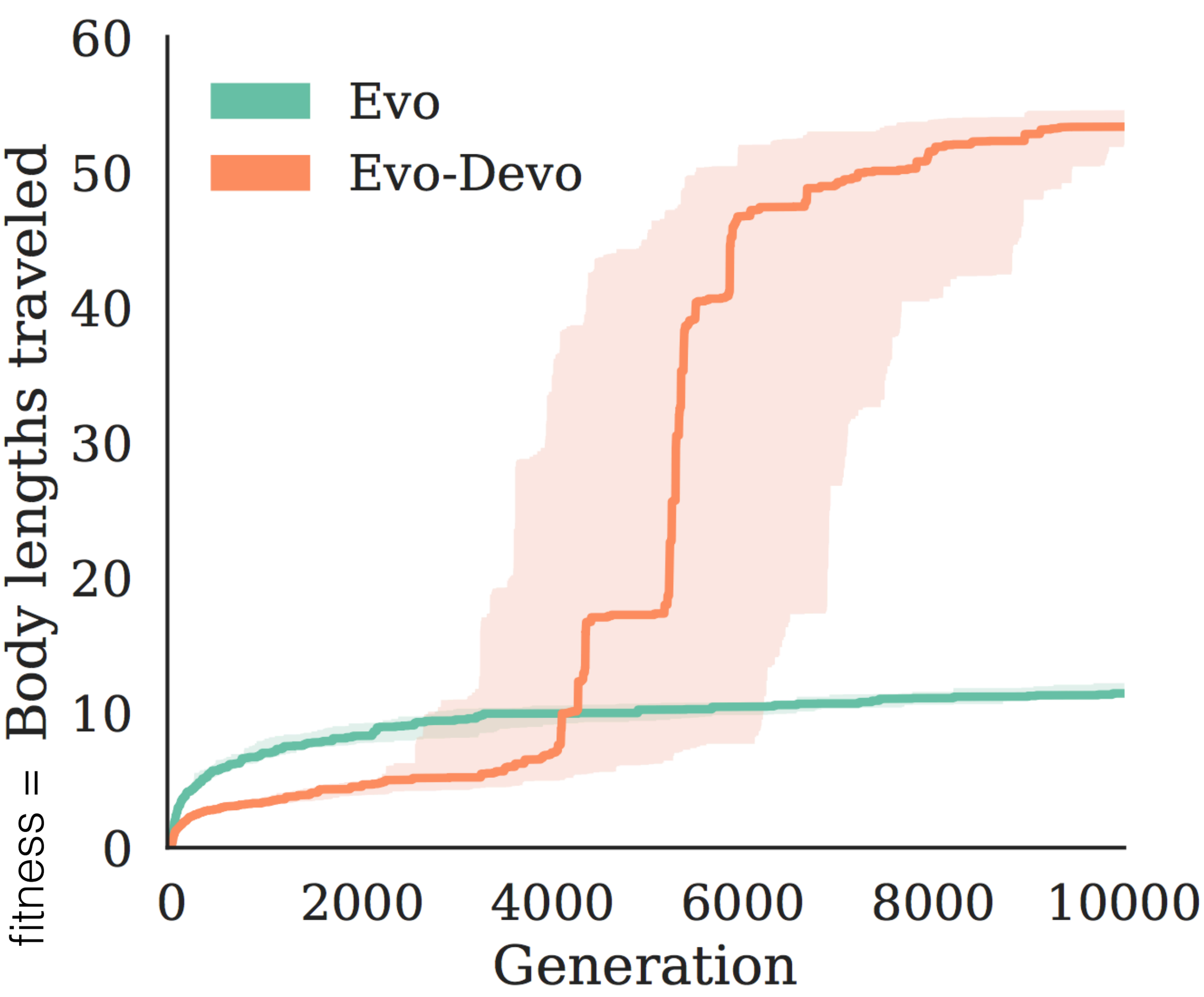
Kriegman *et al.* (2017) *Procs of the GECCO conference*.

4x4x3 = 48
evolvable parameters

4x4x3 x2 = 96
evolvable parameters



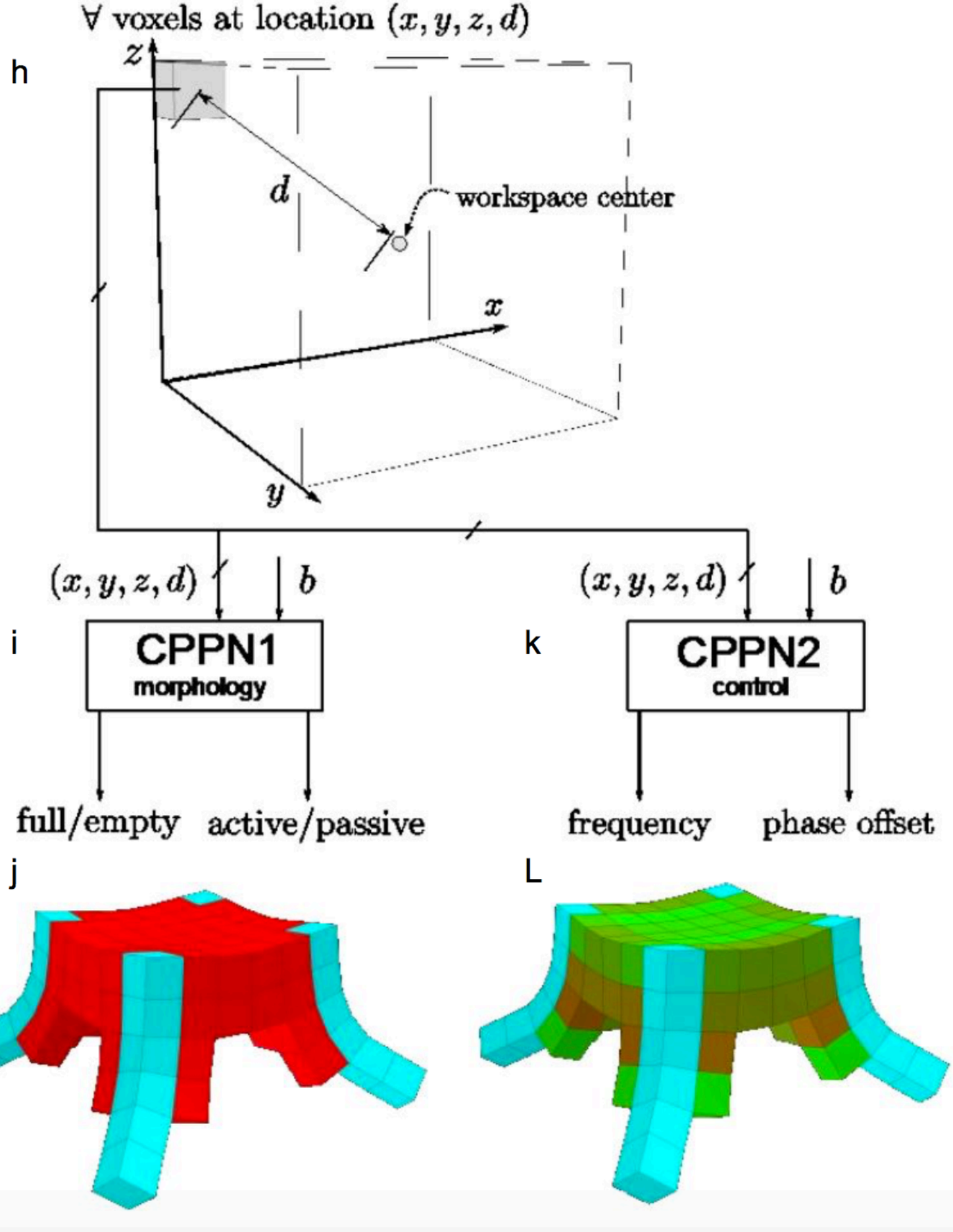
Kriegman *et al.* (2017) *Procs of the GECCO conference*.


Evo
Evo-Devo
fitness = Body lengths traveled
0
10
20
30
40
50
60
0
2000
4000
6000
8000
10000
Generation

Kriegman *et al.* (2017) *Procs of the GECCO conference*.

Corucci, *et al.* (2017)

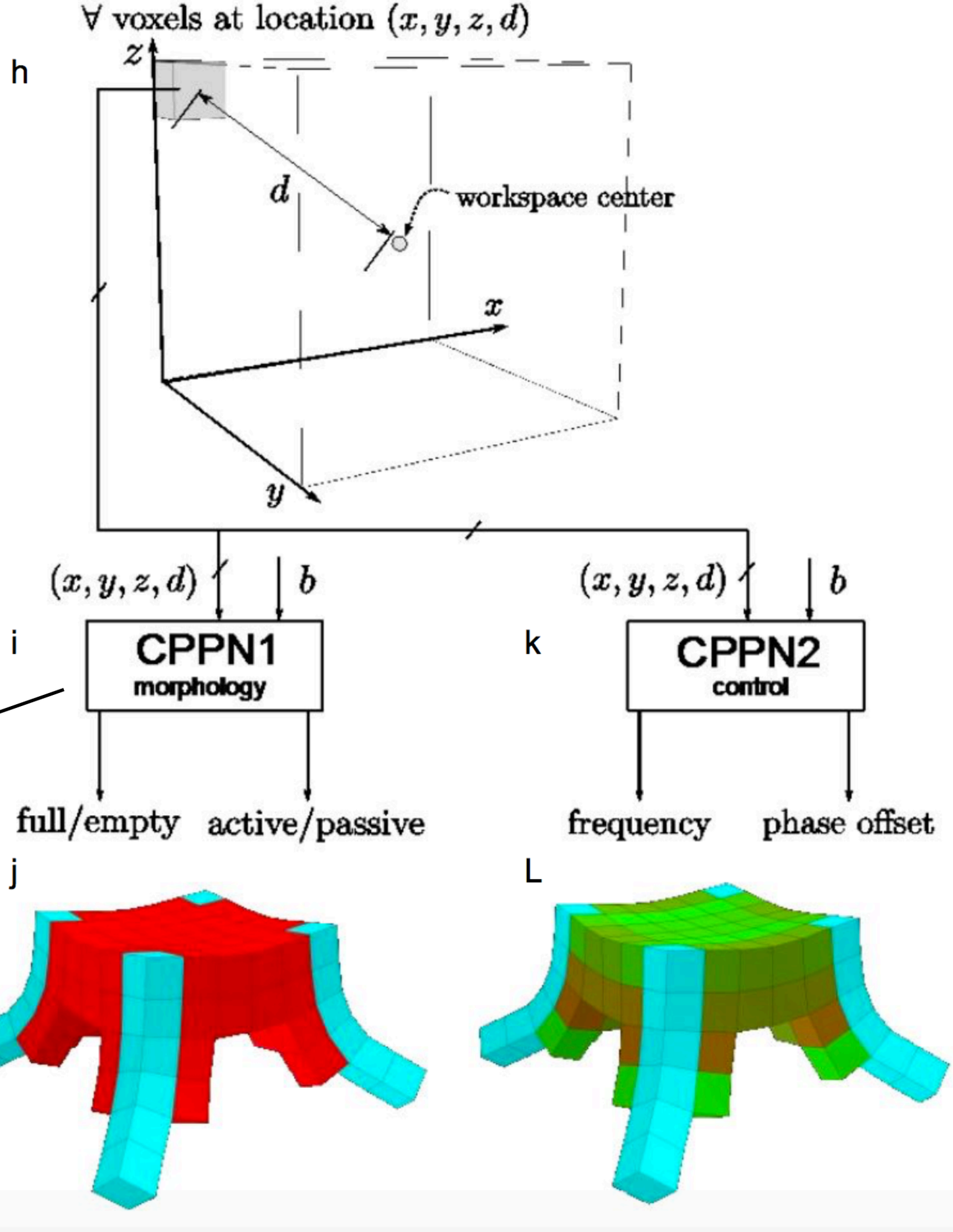
Frontiers in Robotics and AI.



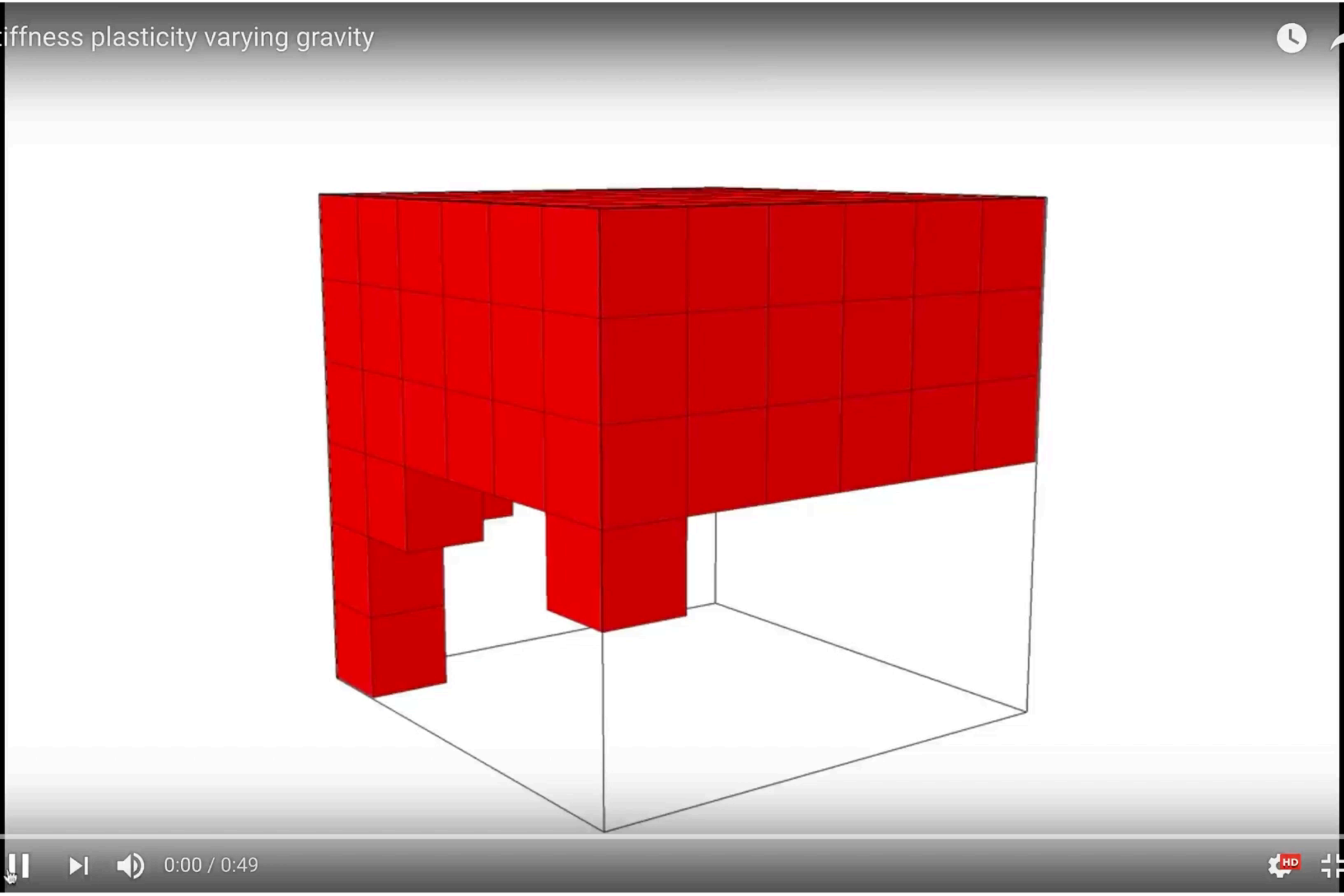
Corucci, *et al.* (2017)

Frontiers in Robotics and AI.

d[stiffness]/d[time] =
alpha ** load*



Corucci e*t al.* (2017) *Frontiers in Robotics and AI*.



Wolff's Law.

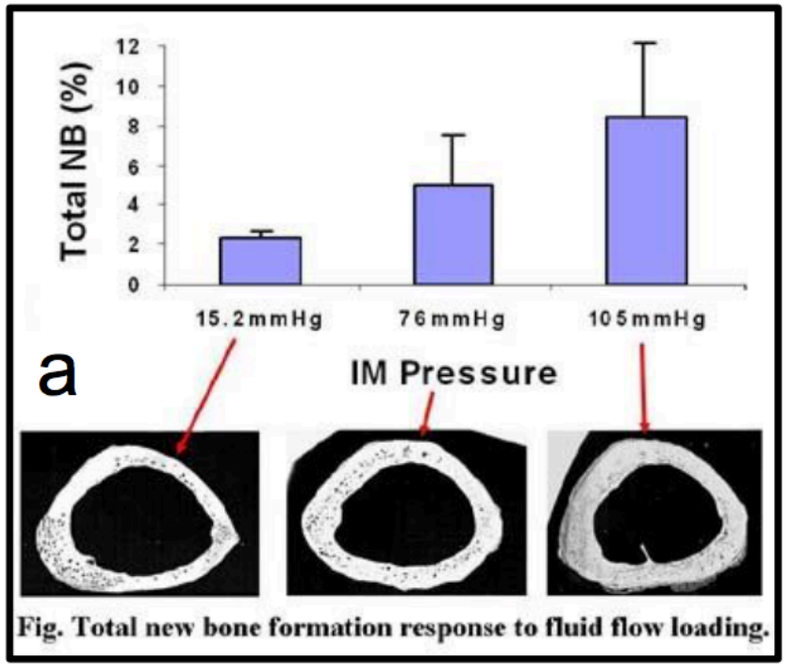


Fig. Total new bone formation response to fluid flow loading.

Code: goo.gl/g5LMka

Automated design: Evolving soft robots. (“Evo SoRo”)

Code: goo.gl/g5LMka

Cheney, MacCurdy, Clune, & Lipson. (2013). *Procs. of the GECCO Conference.*

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Evolving regular patterns in space: CPPNs

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Evolving morphology and control independently.

Cheney, Bongard, SunSpiral, Lipson (2017). *arXiv.*

Evolving regular patterns in <u>time</u>: Evolving soft robots that develop (“Evo Devo SoRo”).

Corucci *et al.* (2017). *Frontiers in Robotics & AI.*

Corucci *et al.* (2017) *Soft Robotics*. In review.

Kriegman *et al.* (2017). *Procs of the GECCO Conference*.

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Corucci *et al.* (2017) *Soft Robotics*. In review.

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