

Bifurcation Revisited Towards Interdisciplinary Applicability

FH-Prof. Mag. DI Dr. Bernhard Heiden, MBA
MMag. Bianca Tonino-Heiden
Volodymyr Alieksieiev, B.Sc.

Studiengang Wirtschaftsingenieurwesen (WING/IEM) & Maschinenbau
(MB), FH-Kärnten

07/14-15/2021 Online - Virtual - London

computing
conference 2022



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Introduction

Introduction:

- Chaos Theory
- Computer Algebra: Mathcad, Matlab
- Nonlinearity, ODEs, Bifurcation Analysis

Goal & Limitations:

- (1) Possibility of applications of bifurcation analysis
 - (2) Examples of computer algebra applications
 - (3) Methodology for bifurcation analysis in interdisciplinary applications
- (*) Small set of problems, programs, theoretical-qualitative gap - Hard and Soft Sciences

Bifurcation revisited I

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```
fun = @(x,r) r*cosd(90-x*180);
x0 = .1; a0 = 0; a1 = 4; N = 200; L = 50;
mat = yue_bifur(fun,x0,a0,a1,N,L,.1);
grid on
```

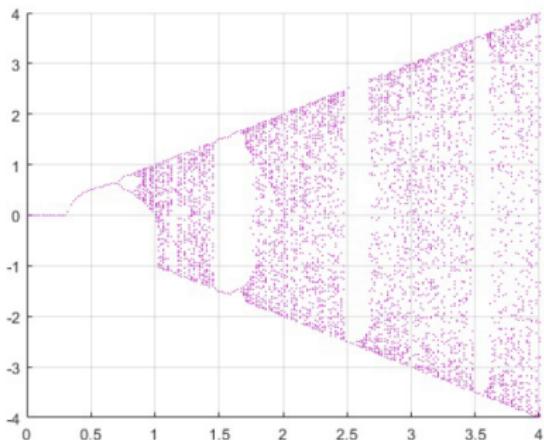


Figure 1: Bifurcation diagram.

Bifurcation revisited II

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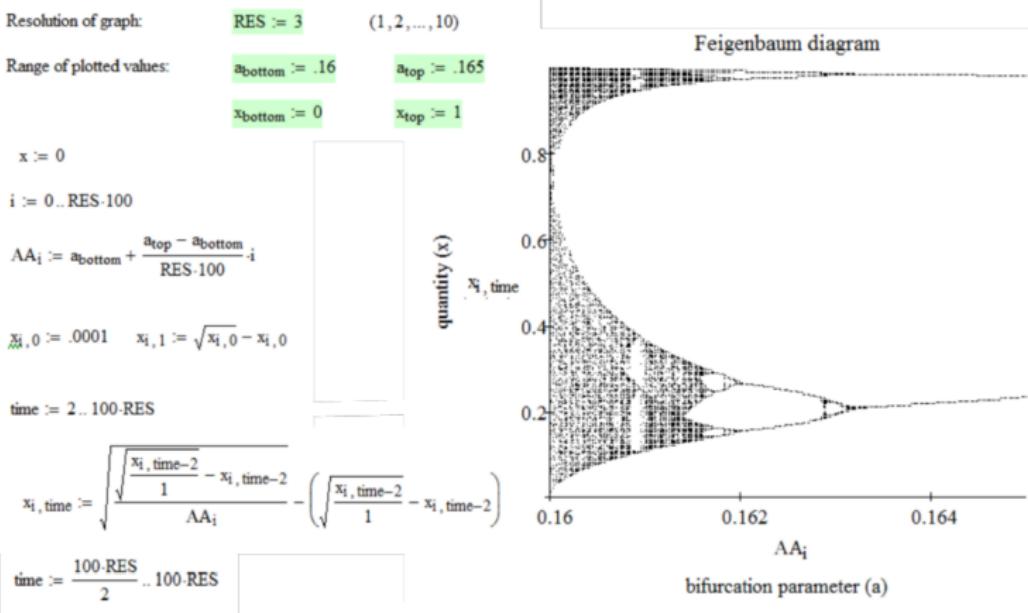


Figure 2: Feigenbaum diagram in Mathcad 15 according to Thiemer, 2001; Puu, 2000.

Bifurcation revisited III

Suggested bridging of Hard and Soft Sciences:

- (1) Design Problem
- (2) Identification Problem

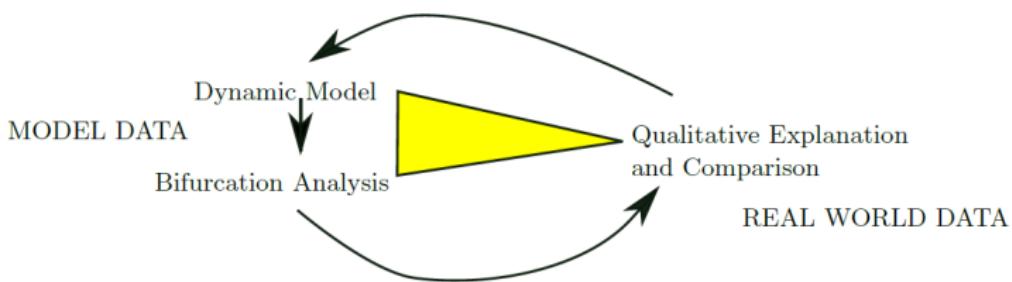


Figure 3: Bifurcation analysis as quantitative-qualitative model mediator.

Summary, Conclusions and Outlook I

Summary and Conclusions:

- Quantification of soft sciences in complex applications with bifurcation analysis
- Use of computational methods: Matlab, Mathcad
- Generic method how to increase knowledge and calculations of 'soft-science' complexity with bifurcation analysis → as bridging tool for hard and soft sciences
- Translate linguistic models into mathematical ones → accelerated theory and knowledge development

Outlook:

- Societal interaction process
- Application to equation based 'social mechanics', production processes, system analysis...

Thank you cordially for your attention!



**FH-Prof. Mag. DI Dr. Bernhard Heiden¹, MBA & MMag.
Bianca Tonino-Heiden, and Volodymyr Alieksieiev, B.Sc.**

¹Professor for Production Engineering

E-Mail: b.heiden@cuas.at

PS.: The presentation can later also be found at:

<http://www.dr-heiden.com/Vortraege.htm>

Bibliography I

- Banerjee, Sanjibani, William A. Barnett, Evgeniya A. Duzhak, and Ramu Gopalan (2011). "Bifurcation Analysis of Zellner's Marshallain Macroeconomic Model". In: URL: <https://mpra.ub.uni-muenchen.de/30059/> (visited on 11/14/2021).
- Bell, J. S. (1964). "ON THE EINSTEIN PODOLSKY ROSEN PARADOX". In: Physics 1.3. Physics Publishing Co., pp. 195–200. URL: https://cds.cern.ch/record/111654/files/vol1p195-200_001.pdf (visited on 12/30/2021).
- Dhooge, A., Govaerts W., Yu. A. Kuznetsov, H. G.E. Meijer, and B. Sautois (Apr. 2008). "New features of the software MatCont for bifurcation analysis of dynamical systems". In: 14.2, pp. 147–175. DOI: [10.1080/13873950701742754](https://doi.org/10.1080/13873950701742754).

Bibliography II

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disciplinary
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*



- Einstein, A., B. Podolsky, and N. Rosen (May 1935). "Can Quantum-Mechanical Description of Reality Be Considered Complete?" In: *Phys. Rev.* 47. 15. May, pp. 777–779.
- Götschl, Johann (1995). "Self-Organization: New Foundations Towards a General Theory of Reality". In: *Revolutionary Changes in Understanding Man and Society - Scopes and Limits*. Ed. by Johann Götschl. Theory and Decision Library. Series A: Philosophy and Methodology of the Social Sciences. Dordrecht/Boston/London: Kluwer Academic Publishers, pp. 109–128. ISBN: 1-4020-0063-4.
- Grossberg, Stephen (2021). *Conscious Mind, Resonant Brain: How Each Brain Makes a Mind*. OXFORD UNIV PR. 768 pp. ISBN: 0190070552.



Bibliography III

- Heiden, Bernhard, Volodymyr Alieksieiev, and Bianca Tonino-Heiden (2021). "Selforganisational High Efficient Stable Chaos Patterns". In: *Proceedings of the 6th International Conference on Internet of Things, Big Data and Security - Volume 1: IoT BDS, INSTICC*. SciTePress, pp. 245–252. ISBN: 978-989-758-504-3. DOI: 10.5220/0010465502450252.
- Heiden, Bernhard and Bianca Tonino-Heiden (2022). "Emergence and Solidification-Fluidisation". In: *LNNS 296*. Intelligent Systems Conference (Intellisys) 2021, Amsterdam, The Netherlands, fully virtual conference, 2-3 September 2021. Ed. by Kohei Arai. Lecture Notes in Networks and Systems. Springer Nature Switzerland AG, pp. 845–855. DOI: 10.1007/978-3-030-82199-9_57.

Bibliography IV

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*

Heiden, Bernhard, Bianca Tonino-Heiden,
Volodymyr Alieksieiev, and Erich Hartlieb (2021).
“Digitisation Model Innovation System”. In: *2021 10th International Conference on Industrial Technology and Management (ICITM)* (University of Cambridge, Cambridge, United Kingdom). Ed. by Meghan O’Dell. Online. IEEE, pp. 128–133. DOI: [10.1109/ICITM52822.2021.00030](https://doi.org/10.1109/ICITM52822.2021.00030).

Bibliography V

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*

Heiden, Bernhard, Bianca Tonino-Heiden, Volodymyr Alieksieiev, Erich Hartlieb, and Denise Foro-Szasz (2021). "Lambda Computatrix (LC) - Towards a Computational Enhanced Understanding of Production and Management". In: *Proceedings of Sixth International Congress on Information and Communication Technology: ICICT 2021* (London, United Kingdom - online, February 25-26 2021). Ed. by Xin-She Yang, Simon Sherratt, Nilanjan Dey, and Amit Joshi. Vol. 236. Lecture Notes in Networks and Systems. Springer Nature Singapore Pte Ltd., pp. 37–46. DOI: [10.1007/978-981-16-2380-6_4](https://doi.org/10.1007/978-981-16-2380-6_4).

Bibliography VI

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*



- Heiden, Bernhard, Matthias Volk, Volodymyr Alieksieiev, and Bianca Tonino-Heiden (2021). "Framing Artificial Intelligence (AI) Additive Manufacturing (AM)". In: *Procedia Computer Science*. 14th International Symposium "Intelligent systems" (INTELS'20), 14.-16. Dec. 2020 (Lomonosov Moscow State University, Online). Vol. 186. Moscow, Russia: Elsevier B.V., pp. 387–394. DOI: [10.1016/j.procs.2021.04.161](https://doi.org/10.1016/j.procs.2021.04.161). URL: <http://intels-conf.ru/>.
- Hilborn, Robert C. (1994). *Chaos and Nonlinear Dynamics - An Introduction for Scientists and Engineers*. Oxford University Press, New York.

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Towards Inter-
disciplinary
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*



Juratoni, Adina and Olivia Bundau (Jan. 1, 2010). "Hopf bifurcation analysis of the economical growth model with logistic population growth and delay". In: *Annals of DAAAM & Proceedings*. ISSN: 1726-9679. URL: <https://www.thefreelibrary.com/Hopf%20bifurcation%20analysis%20of%20the%20economical%20growth%20model%20with...-a0246014085> (visited on 11/14/2021).



Luhmann, Niklas (2018a). *Die Gesellschaft der Gesellschaft*. 10th ed. Suhrkamp Verlag, Frankfurt/Main. 1164 pp.



— (2018b). *Soziale Systeme*. 17th ed. Suhrkamp Verlag AG. 675 pp. ISBN: 3518282662.



Puu, T. (2000). *Attractors, Bifurcations, and Chaos. Nonlinear Phenomena in Economics*. Berlin et al. (cit. on p. 5).

Bibliography VIII

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Towards Inter-
disciplinary
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*



Ritterskamp, Daniel, Güven Demirel, Bart L. MacCarthy, Lars Rudolf, Alan R. Champneys, and Thilo Gross (July 2018). "Revealing instabilities in a generalized triadic supply network: A bifurcation analysis". In: 28.7, p. 073103. DOI: [10.1063/1.5026746](https://doi.org/10.1063/1.5026746).

Sharma, Sanjiv, Etienne B. Coetzee, Mark H. Lowenberg, Simon A. Neild, and Bernd Krauskopf (Sept. 2015). "Numerical continuation and bifurcation analysis in aircraft design: an industrial perspective". In: 373.2051, p. 20140406. DOI: [10.1098/rsta.2014.0406](https://doi.org/10.1098/rsta.2014.0406).



Thiemer, Andreas (2001). *Duopoly — Part II: Lost in Fractals*. URL: https://www.fh-kiel.de/fileadmin/data/wirtschaft/dozenten/thiemer_andreas/mcd/duopol2.pdf (visited on 11/15/2021) (cit. on p. 5).

Bibliography IX

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Conclusions
and Outlook

*

Tonino-Heiden, Bianca, Bernhard Heiden, and

Volodymyr Alieksieiev (2021). "Artificial Life - Investigations about a Universal Osmotic Paradigm (UOP)". In: *Intelligent Computing, LNNS*. Computing Conference 2021, 15.-16. July 2021. Ed. by K. Arai. Vol. 285. Virtual / London: Springer Nature, pp. 595–605. DOI: [10.1007/978-3-030-80129-8_42](https://doi.org/10.1007/978-3-030-80129-8_42).

Villari, M., M. Fazio, S. Dustdar, O. Rana, and R. Ranjan (2016). "Osmotic computing: A new paradigm for edge/cloud integration". In: *IEEE Cloud Computing* 3, pp. 76–83.

Weremczuk, Andrzej, Rafal Rusinek, and Jerzy Warminski (2018). "Bifurcation and stability analysis of a nonlinear milling process". In: Author(s). DOI: [10.1063/1.5019093](https://doi.org/10.1063/1.5019093).

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*

Wu, Yue (Mar. 3, 2010). *Function yue_bifur: plots 1D
bifurcation figure.* URL:

[https://www.mathworks.com/matlabcentral/mlc-
downloads/downloads/submissions/26839/versions/
1/previews/yue_bifur.m/index.html](https://www.mathworks.com/matlabcentral/mlc-downloads/downloads/submissions/26839/versions/1/previews/yue_bifur.m/index.html) (visited on
11/14/2021).