Prioriteitenprogramma

Niet Lineaire Systemen

Populatiedynamica

News Letter

A newsletter for the project ‘Population dynamics, including epidemiology’ being part of the NWO priority program ‘Nonlinear Systems’.

May 18, 2000

Visit the Home Page on:
`http://www.bio.vu.nl/nls/`

This newsletter will appear once every three months during the course of the project. Its content will mainly consist of announcements of activities, such as seminars and workshops. Moreover, information about foreign visitors being in the Netherlands as part of the program will be given.

To make this newsletter as informative as possible we ask you to let us know about activities that are planned and the date visitors are coming and give lectures. Also addresses of persons (in the Netherlands or abroad) who might be interested in receiving this newsletter are welcome.

Contributions to this newsletter were made by: Martin Boer, Bob Kooi.

All correspondence should be sent to:
Bob Kooi
Theoretical Biology
Vrije Universiteit
De Boelelaan 1087
1081 HV Amsterdam

Email: `kooi@bio.vu.nl`

Contents

1 Summary of PhD-thesis

Summary of the PhD-thesis by **Martin Boer** Tuesday 27th 2000, Email: `mpboer@bio.vu.nl`

The Dynamics of Tritrophic Food Chains

This thesis treats theoretical aspects of the dynamics of a tri-trophic food chain composed of a prey, a predator, and a top-predator. Several food chain models are investigated. All these models are described by a system of ordinary differential equations. Research in the last 10 years has shown that tri-trophic food chain models exhibit a rich set of dynamical behavior, including chaotic behavior and multiple attractors. The aim of the investigations that are presented in this thesis is to clarify some aspects of the complicated behavior of these tri-trophic food chain models.

One of the central themes of this thesis is the numerical computation of connecting orbits. The existence of these connecting orbits has important consequences on the dynamics of the tri-trophic food chain. Two types of connecting orbits that are found in tri-trophic food chain models are discussed. The first type is a homoclinic orbit of a saddle cycle. The other type is a heteroclinic orbit between a saddle equilibrium and a saddle cycle.

Another main topic is the computation of the basins of attraction of the tri-trophic food chain models. If the tri-trophic food chain model has two attractors, the domains of attraction are separated by the stable manifold of a limit cycle of saddle type. A continuation method is used to compute this separatrix. The separatrix can have a complex structure when the system has heteroclinic orbits.

Bifurcation analysis of the tri-trophic food chain model is the third central theme of this dissertation. The resulting bifurcation diagrams classify all possible modes of behavior of the system and transitions between them under parameter variations. One of the most remarkable transitions that can be observed in tri-trophic food chain models is the sudden disappearance of a chaotic attractor. This transition is related to a homoclinic bifurcation of a saddle cycle. At a homoclinic bifurcation the stable and unstable manifold of the saddle cycle have a tangency along a non-transversal homoclinic orbit.

A fourth central topic is to compare the dynamics of a continuous-time food chain model with the dynamics of a simple one-dimensional discrete-time system. This comparison of the dynamics of these two systems is motivated by the fact that the next-return map of the chaotic attractor of the tri-trophic food chain is essentially one-dimensional. It is shown that a large part of the complicated bifurcation structure of the tri-trophic food chain can be understood from the local and global bifurcations of a cubic map. The cubic map has two turning points, a maximum and a minimum. The dynamics of this cubic map are analysed in great detail and compared with the dynamical behavior of the original tri-trophic food chain model.

Chapter 1 gives an introduction in tri-trophic food chain dynamics. First, the dynamics of a Lotka-Volterra-based tri-trophic food chain model is described. This simple model can be analysed in great detail. Using this model some basic concepts of bifurcation theory are introduced. The drawbacks of the classic Lotka-Volterra model are discussed. Finally, a

general formulation of the tri-trophic food chain models that are described in this thesis is given.

In chapter 2 a microbial food chain in the chemostat is presented. The model equations are derived from a dynamic energy budget model formulated at the individual level. This model exhibits a chaotic attractor. In some regions of the parameter space there are multiple attractors. The bifurcation diagrams of this food chain model show a complex cascade of intersecting tangent and flip bifurcations of limit cycles.

Chapter 3 treats the dynamics of the Monod-Herbert model of a microbial food chain in the chemostat. The Monod-Herbert model is a simplification of the dynamic energy budget model described in chapter 2. It is shown that the bifurcation structure of the food chain model has much in common with the bifurcation structure of a one-dimensional cubic map with two turning points. This map is used to explain how chaotic attractors are created and destroyed under variation of the bifurcation parameters. Two global bifurcation curves can be found for this tri-trophic food chain, a homoclinic bifurcation of a saddle cycle and a heteroclinic bifurcation of an equilibrium and a limit cycle. It is shown that a high concentration of input substrate can lead to extinction of the top-predator population.

Chapter 4 deals with the dynamics of a tri-trophic food chain model with logistic prey. The investigations that are presented in this chapter focus on the computation of global bifurcations. These bifurcations are associated with the appearance of heteroclinic and homoclinic orbits to a limit cycle of saddle type. It is shown that a homoclinic bifurcation curve bounds a region of extinction of the top-predator. This region of extinction is surrounded by a region of chaotic coexistence. It is shown that, if there are multiple attractors, the existence of heteroclinic orbits from an equilibrium to a periodic orbit has important consequences for the domains of attraction.

In chapter 5 the Monod model of a tri-trophic food chain in the chemostat is analysed. The Monod model is a further simplification of the Monod-Herbert model, as described in chapter 3. The advantage of the Monod model, from a mathematical point of view, is that it can be reduced to a three-dimensional system. The dynamics of the next-return map of a Poincaré section can be analysed in great detail. Numerical results strongly suggest that the two-dimensional invertible next-return map is almost one-dimensional. The analysis in this chapter explains why the complex bifurcation structure of a tri-trophic food chain model has essential features of the dynamics of a one-dimensional discrete time system.

2 Calendar

June 7, 2000

Colloquium Modelling and Analysis in the Life Sciences
Time: June 7 2000, 10:00-12:30
Location: CWI, Room Z009room F123, Vrije Universiteit, de Boelelaan 1087, Amsterdam
Route description: `http://www.cwi.nl/cwi/about/index.html`

Program
10.30 - 11.15 Prof. dr. H. V. Westerhoff (Free University, Amsterdam)
Attempting to be quantitative in the living cell
11.30 - 12.15 Prof. dr. J. P. Keener (University of Utah) *How quorum sensing works*
12.30 - 13.45 lunch (in the Newton Room)
14.00 - 14.45 Prof. dr. O. Diekmann (University of Utrecht)
A framework for structured population models
15.00 - 15.45 Dr. A. M. de Roos (University of Amsterdam)
Flexible, individual behaviour and the dynamics of size-structured populations

The lunch is offered by the CWI and there is no fee for participation. In order to estimate the number of participants, however, we would ask you to inform Nada Mitrovic (`Nada.Mitrovic@cwi.nl`,Tel. 020-5924233) if you plan to attend.
Info: Dr. Mark Peletier, `Mark.Peletier@cwi.nl`, Tel. 020-5924226,

June 27, 2000

Mini symposium Food web dynamics
Time: Tuesday 27 June 2000, 10:00-12:30
Location: room F123, Vrije Universiteit, de Boelelaan 1087, Amsterdam
Route description: `http://www.vu.nl/Algemeen/route.html`

Program symposium on the occasion of the PhD defence of Martin Boer
10.00 Coffee
10.15 Martin Boer (Wageningen UR) *The dynamics of tri-trophic food chains*
10.45 Sergio Rinaldi (Milaan) *Peak-to-peak dynamics in food chains*
11.30 Marten Scheffer (Wageningen UR) *Between models and reality*
12.15 Break
13.45 Promotie Martin Boer (Auditorium, Vrije Universiteit Amsterdam)

Info: Bob Kooi, Dept. Theor. Biol., Faculty of Biology, Vrije Universiteit Amsterdam `kooi@bio.vu.nl`, Tel. 020 4447129

August 23-27, 2000

Second international conference on deterministic and stochastic modeling of biointeraction

Information:

Fabio Augusto Milner — Email : destobio@math.purdue.edu
West Lafayette, Indiana, USA — http://www.math.purdue.edu/~milner/DESTOBIO_2000.html

September 4-15, 2000

SPATIAL STRUCTURES IN BIOLOGY AND ECOLOGY: MODELS AND METHODS

The European Society for Mathematical and Theoretical Biology (ESMTB) is happy to announce a Biomathematics Summer School to be held in Martina Franca (Taranto, Italy) September 4-15, 2000.

Presentation

Spatial structures" are those biological and ecological entities whose functions depend on the spatial relationship of their components. Examples in biology include morphogenesis, pattern formation, angiogenesis, tumor growth, chemotaxis, cytoskeletal mechanics, rabies propagation, seasonal bird migrations, patchy structure of plankton and fish populations.

Spatially distributed processes can be modelled at different scales, depending on the features of interest and on the level of aggregation of their components. Scaling is associated with the choice of representation: from discrete to continuous, from stochastic to deterministic, from ordinary to partial to stochastic differential equations, from cellular automata to particle systems, from mean-fields to individual-based models.

The purpose of the school is to present recent advances and offer interdisciplinary training in the modeling and the study of spatial structures encountered in biology and ecology. The approach will consist in the presentation of real life examples together with the treatment of the models by which these examples may be represented, with the perspective of extracting generally valid and useful methods and techniques.

The target audience is composed of advanced graduate students and post-doctoral researchers. Individuals with a mathematical background (mathematics, applied math., physics, engineering) interested in biological problems, as well as participants from the biological fields (ecology, biology, medicine, natural sciences, etc) willing to employ mathematical techniques in the study of their problems, are encouraged to apply.

The school will be mainly composed of parallel courses (see below), whose teaching will be conducted in 40 minute units with breaks in between. Each course is conceived as a whole, with a reasonable number of goals to be achieved by the end of it. The basic material needed for understanding the course shall be classical and otherwise an appropriate introduction will be included. Concise course materials will be distributed on the first day of the school. In addition to the courses, there will be invited conferences (40mn) and communications by participants (20mn).

Courses (instructors)

Morphogenesis (P. Maini, N.A.M. Monk, E. Plathe, G.F. Oster)
Taxis and diffusion (T. Hillen, A. Stevens)
Modelling cell migration (M. Chaplain)
Time scales and space (R. Bravo de la Parra: P. Auger, J.C. Poggiale, E. Sánchez)
Metapopulation dynamics (M. Gyllenberg)
Interacting particles and stochastic differential equations (V. Capasso, S. Gueron)
Computer simulation of populations (A. Deutsch, A. Lomnicki, C. LePage)
Estimation (A. De Gaetano)

Numerical methods (L.M. Abia, J.C. López-Marcos)

Conference schedule The school begins on Monday, September 4, 2000. The duration of the school is two weeks, including 10 days of classes, Monday through Friday. Each day there will be 8 lecture units of 40 min by the staff and by invited speakers, as well as two 20 min lectures contributed by participants.
Location Martina Franca is a small town in southern Italy, in the Puglia countryside with olive groves, prickle pears and the renowned "trulli" archaic houses. The medieval town centre, enclosed by the city walls, is very pleasant to stroll about, and includes a Ducal Palace, in whose main Hall the school's lectures will be held. Weather is mild to warm, sunny most of the time. Martina Franca may be reached by plane (Bari airport), train or bus.
ACCOMODATION Participants will be lodged at the Park Hotel S. Michele; it is a nice hotel, with a well kept garden and a large swimming pool. The Lectures will be at the Palazzo Ducale (City Hall), within short walking distance, at the Sala Arcadia.
Deadlines

- Scholarship applications: April 30th, 2000
- Communication of scholarship attributions: May 30th, 2000
- Reduced-fee registrations: June 30th, 2000

Information:
If you are interested in coming to the school, please e-mail the following information to `martina.franca@uni.uah.es`, and you will be kept up-to-date with all developments. Updated information about the school as well as a direct web contact form is to be found on the web page:
URL:`http://www.mat.unimi.it/~miriam/ismtb/martina-ss/summer_school.html`

October 8-12, 2000

Symposium on Trends in Nonlinear Analysis - TiNA 2000.
Location: Communication Center of the "Deutsches Krebsforschungszentrum" (DKFZ) on the Campus of the University of Heidelberg, Im Neuenheimer Feld 280.

The understanding of nonlinear phenomena has become a central theme in applied mathematics. The aim of this conference is to discuss the challenges applied nonlinear analysis has to face given the increased diversity of scientific problems.
A sections for contributed talks and section organizers
A. PATTERNS AND DYNAMICS Bernold Fiedler, Freie Universität Berlin and Angela Stevens, MPI for Mathematics in the Sciences, Leipzig
B. EVOLUTION EQUATIONS Hans Engler, Georgetown University, Washington
C. MATHEMATICAL BIOLOGY Wolfgang Alt, Friedrich-Wilhelms-Universitaet Bonn and Horst Thieme, Arizona State University, Tempe
D. MULTISCALE PROBLEMS Andro Mikelic, Universite Claude Bernard Lyon 1 and Felix Otto, Friedrich-Wilhelms-Universität Bonn
E. NUMERICAL ANALYSIS Jozef Kacur, Comenius University, Bratislava and Dietmar Kroener, Albert-Ludwigs-Universität Freiburg
F. QUALITATIVE PROPERTIES OF ELLIPTIC AND PARABOLIC EQUATIONS Steffen

Heinze, MPI for Mathematics in the Sciences, Leipzig and Bernd Kawohl, Universität zu Köln

How to contribute
Participants are encouraged to apply to give an oral presentation of 30 minutes in one of the above sections. The conference language is English. Please see our webpage `http://www.iwr.uni-heidelberg.de/tina2000/contributions.html` for details on submission of abstracts. There you find the LaTeX- classfile, a template for your two pages of reviewable abstract, and the e-mail address `submit-tina2000@iwr.uni-heidelberg.de` where to send the abstract. The number of contributions is limited to about 50. Acceptance is based on a review process - the decision will be made by beginning of July.
Deadlines

- for submission of abstracts April 28, 2000
- for registration August 31, 2000
- for payment August 31, 2000

Conference fee
The registration fee is 100 EURO. A registration form is now available on our webpage. The late registration fee is 150 EURO (payment after September 1, 2000).
Invited speakers Constantine M. Dafermos (Brown University, Providence)
Peter Deuflhard (Konrad-Zuse-Zentrum, Berlin)
Odo Diekmann (Universiteit Utrecht, Utrecht)
Gerhard Dziuk (Albert-Ludwigs-Universitaet Freiburg)
Paul C. Fife (University of Utah, Salt Lake City)
Avner Friedman (University of Minnesota, Minneapolis)
Karl-Heinz Hoffmann (TU Muenchen and Stiftung CAESAR, Bonn)
Frank C. Hoppensteadt (Arizona State University, Tempe)
Gerhard Huisken (Universitaet Tuebingen and Princeton University, Princeton)
Masayasu Mimura (Hiroshima University, Hiroshima)
Stefan Mueller (MPI for Mathematics in the Sciences, Leipzig)
James D. Murray (University of Washington, Seattle)
Jindrich Necas (Northern Illinois University, Dekalb)
Vladimir Oliker (Emory University, Atlanta)
George C. Papanicolaou (Stanford University, Stanford)
Nina Nikolaevna Uraltseva (St. Petersburg State University, St. Petersburg)
Paul Waltman (Emory University, Atlanta)

Information:
Email : `tina2000@iwr.uni-heidelberg.de`
URL:`http://www.iwr.uni-heidelberg.de/tina2000/`
Fax: +49 (0) 6221 54 8652

June 3-8, 2001

6th Int. Conference on Mathematical Population Dynamics, Marrakech, Morocco, June 3-8, 2001

Organized by: The Department of Mathematics, Chalmers University of Technology and the University of Göteborg, Göteborg, Sweden
and Le Centre Internationale de Formation et de Recherche: Systemes Dynamiques Marrakech, Morocco

The sixth International Conference on Mathematical Population Dynamics is an interdisciplinary meeting of biologists and mathematicians concerned with populations of biomolecules, genes, cells and living organisms as well as other topics of mathematical population biology and epidemiology. The meeting will be focused on (both deterministic- and stochastic) mathematical theory, model analysis, and modelling of quantitative data pertaining to cell- and molecular biology, epidemiology, cancer research, population genetics, population biology and other related areas.

Proposals for topics and subjects may be submitted to the conference secretaries.

Please send the application by mail, fax, e-mail or the online form that can be found at the conference home page, preferably before September 1, 1999 to one of the scientific secretaries and mark the envelop "MPD6".

Information:

Conference secretaries: Marina Alexandersson, Ulrica Olofsson, Ziad Taib,
Email: `mpd6@math.chalmers.se`

Department of Mathematics	Chalmers University of Technology and the University of Göteborg
S-412 96 Göteborg, Sweden	http://www.math.chalmers.se/ ziad/popdyn/Mpd6/index.html
Phone +46 31 772 35 30	Fax +46 31 772 35 08