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さくらサイエンスプラン

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JST さくらサイエンスプログラムによる数理科学に関する
日中共同ワークショップ　於松江 2018

Japan–China Joint Workshop on Mathematical Sciences in Matsue 2018
supported by Japan-Asia Youth Exchange Program in Science

島根大学において, 下記の要領で研究集会を開催致しますので, ご案内申し上げます。

世話人　杉江実郎 (島根大学)

記

日　時：　2018 年 11 月 17 日 (土) 10:20〜16:30
　　11 月 18 日 (日) 10:00〜15:20

会　場：　島根大学松江キャンパス
総合理工学部 3 号館数理第 2 総合演習室
〒 690-8504 島根県松江市西川津町 1060
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https://www.shimane-u.ac.jp/access/

プログラム

11 月 17 日

(開会挨拶)

10:30〜10:50　Jiu Li* (北京科技大学)
Hongyan Zang (北京科技大学)
The construction of one-dimensional
discrete chaos theory based on
improved Marotto's theorem

10:50〜11:10　Yan Yan* (島根大学)
Jitsuro Sugie (島根大学)
Existence regions of positive periodic solutions for a mixed discrete hematopoiesis model

11:10〜11:30　Li Bingxiu (北京科技大学)
The method research of long non-coding RNA prediction based on deep learning

11:30〜11:50　Hiroshi Shiozaki* (島根大学)
Jitsuro Sugie (島根大学)
Asymptotic stability for nonlinear differential equations with time-varying coefficients

(昼食)

13:30〜14:10 Yukihiko Nakata (島根大学)【特別講演】
Epidemics with waning immunity

(休憩)

14:20〜14:40 Rong Qiang* (北京科技大学)
Wanbiao Ma (北京科技大学)
Ke Guo (北京科技大学)
The differential equation model of pathogenesis of Kawasaki disease with theoretical analysis

14:40〜15:00 Liu Yang* (島根大学)
Yukihiko Nakata (島根大学)
Epidemics with boosting of immunity

15:00〜15:20 Ke Guo* (北京科技大学)
Wanbiao Ma (北京科技大学)
Global dynamics analysis of a differential equation model of Kawasaki disease pathogenesis

(休憩)

15:30〜15:50 Na Li* (北京科技大学)
Ping Lin (ダンディー大学)
Fuzheng Gao (山東大学)
An expanded mixed finite element method for sobolev equations

15:50〜16:10 Yang Liu** (島根大学)
Takeshi Wada (島根大学)
Long range scattering and modified wave operators for the Maxwell-Schrödinger equation in three space dimensions

16:10〜16:30 Kaiqiang Zhang* (北京科技大学)
Baiyu Liu (北京科技大学)
Finite time blow-up and global existence for the nonlocal hyperbolic equation

11 月 18 日

10:00〜10:40 Hairui Wei (北京科技大学)【特別講演】
Quantum information processing based on artificial atoms

(休憩)

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Guanrong Zeng* (北京科技大学)
Analysis of timeliness of oil price news information based on SVM

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Jitsuro Sugie (島根大学)
Integral averaing technique for oscillation of second-order linear self-adjoint differential equations with impulsive effect

11:30〜11:50 Chunyan Liu* (北京科技大学)
Liancun Zheng (北京科技大学)
Ping Lin (北京科技大学)
Flow and heat transfer of Bingham plastic fluid over a rotating disk with variable thickness

(昼食)

13:30〜13:50 Kazuki Seto* (島根大学)
Daishi Kuroiwa (島根大学)
Arcwise connected quasiconvex functions and its applications

13:50〜14:10 Xingyan Li* (北京科技大学)
Yan Xu (北京科技大学)
Human age prediction based on DNA methylation using a gradient boosting regressor

14:10〜14:30 Hiroyuki Ohtani* (島根大学)
Koji Okano* (島根大学)
Daishi Kuroiwa (島根大学)
Constraint qualifications for the Lagrange-duality of extended real-valued convex optimization problems

(休憩)

14:40〜15:00 Yingxi Yang* (北京科技大学)
Yan Xu (北京科技大学)
iGlu-Lys: A Predictor for lysine glutarylation through amino acid pair order features

15:00〜15:20 Takumi Murakami* (島根大学)
Yuya Sumida* (島根大学)
Daishi Kuroiwa (島根大学)
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2018 年 10 月 31 日作成

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Organizing Committee
Jitsuro Sugie (Shimane University)

Program

November 17

(Opening Remarks)

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Hongyan Zang (University of Science and Technology Beijing)
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10:50〜11:10 Yan Yan* (Shimane University)
Jitsuro Sugie (Shimane University)
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(Lunch)

13:30〜14:10 Yukihiko Nakata (Shimane University)【Special Lecture】
Epidemics with waning immunity

(Break)

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Yuya Sumida* (Shimane University)
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2018 年 11 月 1 日作成

THE CONSTRUCTION OF ONE-DIMENSIONAL DISCRETE CHAOS THEORY BASED ON IMPROVED MAROTTO'S THEOREM

JIU LI* AND HONGYAN ZANG

In this talk, we consider one-dimensional map in the Chen-Lai alorithm [1] given by the following discrete-time dynamical system

$$x_{k+1} = f(x_k) + (N + e^c)\, x_k \,(\mathrm{mod}1), \tag{1}$$

where $f(x) \in \mathbf{C}^1[0,1]$, and $f(0) = 0$, the control parameters N and c are restricted to be in $|f'(x)| < 1 \leq N$ and $c > 0$. It is proved that system (1) exists chaos in the sense of Li-Yorke [2] from the point of chaos anti-control idea. Actually, such equation (1) is via the origin, namely, let $x_k = 0$ one obtains that $x_{k+1} = 0$. Therefore, this talk intends to deal with the mathematical model with modulo operation

$$x_{k+1} = f(x_k)\,(\mathrm{mod}1), \tag{2}$$

where $f(x) \in \mathbf{C}^1[0,1]$, and $f(0) \notin \mathbf{Z}$. Obviously, let $x_k = 0$ one gets that $x_{k+1} \neq 0$. We simply mark the derived map from the system (2) to $g(x)$

$$g(x) := f(x)\,(\mathrm{mod}1), \tag{3}$$

where $f(x) \in \mathbf{C}^1[0,1]$, and $0 < g(0) < 1$.

In the map (3), given that $f(x)$ is divided into two cases: strictly monotonically increasing and strictly monotonically decreasing, we analyze the existence of their fixed points separately. And using the improved Marotto's theorem [3], the conditions for the existence of chaotic properties are given. To be specific, in order to overcome the traditional structural limitations that a chaotic system can be only through the origin, a one-dimensional discrete-time system with nonzero value as x equaling 0 is firstly given. a systematic methodology can be developed here for designing a one-dimensional discrete-time chaotic system which satisfies some performances.

References

[1] G. Chen and D. Lai, Feedback control of Lyapunov exponents for discrete-time dynamical systems, Internat. J. Bifur. Chaos Appl. Sci. Engrg. **6** (1996), 1341–1349.
[2] T.Y. Li and J.A. Yorke, Period three implies chaos, Amer. Math. Monthly **82** (1975), 985–992.
[3] Y. Shi and G. Chen, Discrete chaos in Banach spaces, Sci. China Ser. A **48** (2005), 222–238.

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Key words and phrases. Chaotic system, Polynomial chaos, Snap-back repeller, Marotto's theorem.

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EXISTENCE REGIONS OF POSITIVE PERIODIC SOLUTIONS FOR A MIXED DISCRETE HEMATOPOIESIS MODEL

YAN YAN* AND JITSURO SUGIE

In 1977, using ordinary differential equations, Mackey and Glass [4] proposed mathematical models to describe the production process of mature blood cells. Their models are divided into two types according to the characteristics of the production function. Since the regulatory mechanisms in hematopoiesis have not yet been completely elucidated, they introduced a monotonically Decreasing function and a Unimodal function in order to express its production process. We call the hematopoiesis models with the former production function and with the latter production function as D-type model (see [1]) and U-type model (see [5]), respectively.

On the other hand, discrete models have attracted attention in biomathematics. Several researchers have pay attention to the study of discrete models of D-type and/or U-type. For example, we refer to the works [2, 3, 6, 7].

In this talk, we combine D-type model and U-type model, and consider a mixed hematopoiesis model

$$\Delta x(k) = -a(k)x(k) + \sum_{i=1}^{p} \frac{b_i(k)x(k-r_i(k))}{1+x^n(k-r_i(k))} + \sum_{j=1}^{q} \frac{c_j(k)}{1+x^n(k-s_j(k))} \tag{1}$$

with $n > 1$ and p, $q \in \mathbb{N}$. We assume that

(i) $a\colon \mathbb{Z} \to (0,1)$ is an ω-periodic discrete function;

(ii) $b_i\colon \mathbb{Z} \to (0,\infty)$, $r_i\colon \mathbb{Z} \to \mathbb{Z}^+$ are ω-periodic discrete functions for $1 \le i \le p$;

(iii) $c_j\colon \mathbb{Z} \to (0,\infty)$, $s_j\colon \mathbb{Z} \to \mathbb{Z}^+$ are ω-periodic discrete functions for $1 \le j \le q$.

We give a sufficient condition for equation (1) to have positive ω-periodic solutions. We also clarify the existence region of the positive ω-periodic solutions.

References

[1] L. Berezansky, E. Braverman and L. Idels, Mackey-Glass model of hematopoiesis with monotone feedback revisited, Appl. Math. Comput. **219** (2013), 4892–4907.

[2] E. Braverman and S.H. Saker, Permanence, oscillation and attractivity of the discrete hematopoiesis model with variable coefficients, Nonlinear Anal. **67** (2007), 2955–2965.

[3] D. Jiang, D. O'Regan and R.P. Agarwal, Optimal existence theory for single and multiple positive periodic solutions to functional difference equations, Appl. Math. Comput. **161** (2005), 441–462.

[4] M.C. Mackey and L. Glass, Oscillation and chaos in physiological control system, Science, New Series, **197** (1977), 287–289.

[5] X.-M. Wu, J.-W. Li and H.-Q. Zhou, A necessary and sufficient condition for the existence of positive periodic solutions of a model of hematopoiesis, Comput. Math. Appl. **54** (2007), 840–849.

[6] Y. Yan and J. Sugie, Existence regions of positive periodic solutions for a discrete hematopoiesis model with unimodal production functions, preprint.

[7] Z. Yao, Existence and global attractivity of the unique positive periodic solution for discrete hematopoiesis model, Topol. Methods Nonlinear Anal. **45** (2015), 423–437.

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Key words and phrases. Discrete hematopoiesis model, Unimodal production function, Positive periodic solutions, Global asymptotic stability, Lyapunov function.

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THE METHOD RESEARCH OF LONG NON-CODING RNA PREDICTION BASED ON DEEP LEARNING

LI BINGXIU

With the rapid development of high-throughput transcriptome sequencing technology, a large number of transcript sequences have been discovered, and how to identify long non-coding RNAs and mRNAs from transcripts is a challenging task. In this paper, we constructed a deep learning model to effectively distinguish long non-coding RNAs from mRNAs. First, in order to extract the context information, we use the unsupervised GloVe algorithm to introduce the feature representation of the RNA sequence and use the k-mer embedding vector instead of the traditional one-hot encoding to get a better feature representation. Then we set up the supervised deep learning framework, including the Bidirectional Long Short-Term Memory model (BLSTM) layer and the convolutional neural network layer with three hidden layers, it is used to extract deep features. Finally, in the supervised training stage, we consider the binary classification as the SoftMax regression of the feature representation, calculating the category probability without the prior assumption of the data distribution, and complete the final classification purpose. We hope that our model will provide effective help in distinguishing between mature RNAs and long non-coding RNAs and become a potential tool to help humans understand the diseases related to detected lncRNAs.

References

[1] R.E. Green, A.S. Malaspinas and J. Krause, et al., A Complete Neandertal Mitochondrial Genome Sequence Determined by High-Throughput Sequencing, Cell **134** (2008), 416–426.

[2] S. Hochreiter and J. Schmidhuber, Long short-term memory, Neural Comput. **9** (1997), 1735–1780.

[3] Y. Kim, Convolutional neural networks for sentence classification, Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing, pp. 1746–1751.

[4] A. Li, J. Zhang and Z. Zhou, PLEK: a tool for predicting long non-coding RNAs and messenger RNAs based on an improved k- mer scheme, BMC Bioinformatics **15** (2014), 311, 10 pp.

[5] X. Min, W. Zeng, N. Chen, et al., Chromatin accessibility prediction via convolutional long short-term memory networks with k-mer embedding, Bioinformatics **33** (2017), i92–i101.

[6] J. Pennington, R. Socher and C. Manning, GloVe: Global vectors for word representation, Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing, pp. 1532–1543.

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ASYMPTOTIC STABILITY FOR NONLINEAR DIFFERENTIAL EQUATIONS WITH TIME-VARYING COEFFICIENTS

HIROSHI SHIOZAKI* AND JITSURO SUGIE

We consider the nonlinear differential equation

$$\big(\phi_p(x')\big)' + f(t,x,x')\phi_p(x') + g(t,x) = 0, \tag{1}$$

where f is a continuous function on $[0,\infty)\times\mathbb{R}^2$, g is a continuous function on $[0,\infty)\times\mathbb{R}$ satisfying $xg(t,x)>0$ for $(t,x)\in[0,\infty)\times\mathbb{R}\backslash\{0\}$ and ϕ_p is a continuous function defined by

$$\phi_p(u) = \begin{cases} |u|^{p-2}u & \text{if } u\neq 0, \\ 0 & \text{if } u=0, \end{cases}$$

with $p>1$. Equation (1) has the only equilibrium $(x,x')=(0,0)$.

In the special case that $f(t,x,x')=h(t)$ and $g(t,x)=\phi_p(x)$, equation (1) becomes the half-linear differential equation

$$(\phi_p(x'))' + h(t)\phi_p(x') + \phi_p(x) = 0. \tag{2}$$

Sugie [2] proved that a necessary and sufficient condition for the equilibrium of (2) to be (globally) asymptotically stable is

$$\int_0^\infty \phi_{p^*}\left(\frac{\int_0^t e^{H(s)}ds}{e^{H(t)}}\right)dt = \infty \tag{3}$$

under the assumption

$$\liminf_{t\to\infty}\int_t^{t+d} h(s)ds > 0, \tag{4}$$

where p^* is a number satisfying $(p-1)(p^*-1)=1$ and $H(t)=\int_0^t h(s)ds$. Note that ϕ_{p^*} is the inverse function of ϕ_p. Although the result in [2] is very sharp, for a concretely given h, it is difficult to judge whether condition (3) is satisfied or not.

In this talk, by using the method of Artstein and Infante [1], we give a condition which can easily guarantee that the equilibrium of (1) (or (2)) is asymptotically stable.

References

[1] Z. Artstain, and E. F. Infante, On the asymptotic stability of oscillators with unbounded damping, Quart. Appl. Math. **34** (1976), 195–199.

[2] J. Sugie, Global asymptotic stability for damped half-linear oscillators, Nonlinear Anal. **74** (2011), 7151–7167.

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Key words and phrases. Nonlinear differential equation, Asymptotic stability.

*Presenting author.

EPIDEMICS WITH WANING IMMUNITY

YUKIHIKO NAKATA

We first formulate an SIRS type epidemic model by delay differential equations, to describe disease transmission dynamics in a population. It is assumed that the duration of individuals immunity, obtained upon the infection, is finite, thus individuals do not acquire lifelong immunity. We analyze stability of equilibria and show that the endemic equilibrium becomes unstable via Hopf bifurcation, as model parameters change. For a special case, following the idea by Kaplan and Yorke (1974), we study the existence of a periodic solution of period 2.

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Key words and phrases. Epidemic models, Waning immunity, Stability, Delay differential equation.

THE DIFFERENTIAL EQUATION MODEL OF PATHOGENESIS OF KAWASAKI DISEASE WITH THEORETICAL ANALYSIS

RONG QIANG*, WANBIAO MA, AND KE GUO

Kawasaki disease, an autoimmune disease , is a systemic vasculitis mainly affecting children younger than 5 years old [3]. Due to the delayed therapy and diagnosis, coronary artery abnormalities develop in children with Kawasaki disease, and leads to a high risk of acquired heart disease. Later, patients may cause myocardial infarction or even sudden death. Unfortunately, at present, the pathogenesis of Kawasaki disease remains unknown and this disease lacks of specific and sensitive biomarkers, which bring difficulties to diagnose and cure [1]. Therefore it is a highly focused topic to research on the pathogenesis of Kawasaki disease. Some scholars believe that Kawasaki disease is caused by the cross reaction of external infection and organ tissue composition, hereby triggering disorder of the immune system and producing a variety of inflammatory factors [1, 2]. On the basis of considering the factors such as inflammatory factors, adhesion factors, endothelial cell growth factors and so on, put forward a kind of dynamic model of pathogenesis of Kawasaki disease by the theory of ordinary differential equation. It is found that the dynamic model can show complex dynamic behavior [4, 5], such as the forward and backward bifurcation of the equilibria. This article reveals the possible complexity of infection of Kawasaki disease, and provides a theoretical references for the research of pathogenisis and clinical treatment of Kawasaki disease.

References

[1] S. Bayers, S.T. Shulman and A.S. Paller, Kawasaki disease: Part I. Diagnosis, clinical features, and pathogenesis, J. Am. Acad. Dermatol. **69** (2013), 501e1–501e11.

[2] C. Galeotti, S.V. Kaveri, R. Cimaz, I. Kon-Paut and J. Bayry, Predisposing factors, pathogenesis and therapeutic intervention of Kawasaki disease, Drug. Discov. Today. **21** (2016), 1850–1857.

[3] T. Kawasaki, Acute febrile mucocutaneous syndrome with lymphoid involvement with specific desquamation of the fingers and toes in children, Arerugi. **16** (1967), 178–222.

[4] M.A. Nowak and C.R.M. Bangham, Population dynamics of immune responses to persistent virus, Science **272** (1996), 74–79.

[5] M.A. Nowak and R.M. May, Virus Dynamics: Mathematical Principles of Immunology and Virology, Nature Medicine **410** (2001), 412–413.

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Key words and phrases. Kawasaki disease, Systemic vasculitis, Differential equation model, Stability.

*Presenting author.

EPIDEMICS WITH BOOSTING OF IMMUNITY

LIU YANG* AND YUKIHIKO NAKATA

We formulate an epidemic model with waning and boosting of immunity by delay differential equations, following the idea by Aron [1, 2]. In the model, recovered individuals may be reinfected because the immune system does not confer long-lasting immunity against a pathogen, thus the immunity wanes. On the other hand, it is also reported that the natural immunity is enhanced by the continued exposure to infection which is called boosting effect. Our main purpose is to explore the effect of the boosting of immunity on the disease transmission dynamics using an epidemic model. We also compare the transmission dynamic with and without boosting effect by numerical simulations.

References

[1] J.L. Aron, Dynamics of acquired immunity boosted by exposure to infection, Math. Biosci. **64** (1983), 249–259.

[2] J.L. Aron, Acquired immunity dependent upon exposure in an SIRS epidemic model, Math. Biosci. **88** (1988), 37–47.

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Key words and phrases. Reinfection, Boosting immunity, Stability, Lambert W function.

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GLOBAL DYNAMICS ANALYSIS OF A DIFFERENTIAL EQUATION MODEL OF KAWASAKI DISEASE PATHOGENESIS

KE GUO*, WANBIAO MA, AND RONG QIANG

Kawasaki disease, also known as mucocutaneous lymph node syndrome (MCLS), was first discovered by Japanese Kawasaki physician in 1967. It is a systemic vasculitis that common occurs in infants and young children [2], if not discovered and treated in time, may induce acquired heart disease, cause coronary artery disease [1]. In order to provide a theoretical basis for the research and clinical treatment of the pathogenesis of Kawasaki disease, Qiang, Ma and Guo [3] proposed model:

$$
\begin{cases}
\dot{E}(t) = r + \dfrac{k_6 V(t) E(t)}{1 + V(t)} - k_1 E(t) P(t) - d_1 E(t), \\
\dot{V}(t) = k_2 E(t) P(t) - d_2 V(t), \\
\dot{C}(t) = k_3 E(t) P(t) + k_4 V(t) - d_3 C(t), \\
\dot{P}(t) = k_5 C(t) - d_4 P(t),
\end{cases} \tag{1}
$$

and gave a complete analysis on the local stability of the equilibria. Where $E(t)$, $V(t)$, C(t) and $P(t)$ represent concentration of normal endothelial cells, vascular endothelial growth factors, activated adhesion factors and chemokines, inflammatory factors in the lesion area at time t in acute stage of Kawasaki disease, respectively. All the parameters are positive constants.

In this talk, the main purpose is to study the global stability of model (1). Sufficient conditions are obtained for the global asymptotic stability, by constructing suitable Lyapunov functions and using Lyapunov-LaSalle invariance principle. In addition, we give some numerical simulations to illustrate our analytical results.

References

[1] H. Kato, Cardiovascular complications in Kawasaki disease: coronary artery lumen and long-term consequences, Prog. Pediatr. Cardiol. **19** (2004), 137–145.

[2] T. Kawasaki, Acute febrile mucocutaneous syndrome with lymphoid involvement with specific desquamation of the fingers and toes in children, Arerugi. **16** (1967), 178–222. (in Japanese)

[3] R. Qiang, W. Ma and K. Guo, The differential equation model of pathogenesis of Kawasaki disease with theoretical analysis, Math. Biosci. (submitted)

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AN EXPANDED MIXED FINITE ELEMENT METHOD FOR SOBOLEV EQUATIONS

NA LI*, PING LIN, AND FUZHENG GAO

Let $\Omega \subset R^2$ be a bounded domain with piecewise smooth boundary $\partial\Omega$. For fixed $0 < T < \infty$, we consider the following initial and boundary value problem:

$$\begin{cases} u_t - \mu\Delta u_t - \gamma\Delta u = f, & (x, y, t) \in \Omega \times (0, T], \\ u(x, y, t) = 0, & (x, y, t) \in \partial\Omega \times (0, T], \\ u(x, y, 0) = \varphi_0(x, y), & (x, y) \in \Omega, \end{cases} \tag{1}$$

where u_t denotes the time derivative of the function u, μ and γ are two positive constants, the source term $f(x, y, t)$ and the initial value function $\varphi_0(x, y)$ are sufficiently smooth.

The purpose of this talk is to introduce the expanded mixed finite element method for the two-dimensional Sobolev equations. We show the existence and uniqueness of the solution of the mixed finite element method, describe the semi-discrete formulation and the fully discrete formulation for Eq. (1), and provide the error estimates of the solution. The optimal error estimates are obtained. Finally, we provide two numerical examples to verify that numerical results are consistent with theoretical conclusions.

References

[1] N. Li, F. Gao and T. Zhang, An expanded mixed finite element method for Sobolev equation, J. Comput. Anal. Appl. **15** (2013), 535–543

[2] W. Liu, H. Rui and H. Guo, A two-grid method with expanded mixed element for nonlinear reaction-diffusion equations, Acta Math. Appl. Sin. Engl. Ser. **27** (2011), 495–502.

[3] D. Shi and Y. Zhang, High accuracy analysis of a new nonconforming mixed finite element scheme for Sobolev equations, Appl. Math. Comput. **218** (2011), 3176–3186.

[4] T. Sun, A Godunov-mixed finite element method on changing meshes for the nonlinear Sobolev equations, Abstr. Appl. Anal. 2012, Article ID 413718, 19 pp.

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LONG RANGE SCATTERING AND MODIFIED WAVE OPERATORS FOR THE MAXWELL-SCHRÖDINGER EQUATION IN THREE SPACE DIMENSIONS

YANG LIU* AND TAKESHI WADA

We consider the scattering theory for the Maxwell-Schrödinger equations under the Lorentz gauge conditions in three space dimensions.

$$\begin{cases} i\partial_t u = -(1/2)\Delta_A u + A_e u \\ \Box A_e = J_0 \\ \Box A = J \end{cases} \tag{1}$$

where (A, A_e) is an $\mathbb{R}^{3+1}$ valued function defined in space time $\mathbb{R}^{3+1}$, $\nabla_A = \nabla - iA$ and $\Delta_A = \nabla_A^2$ are the covariant gradient and covariant Laplacian respectively and $\Box = \partial_t^2 - \Delta$ is the d'Alembertian. $J_0 = |u|^2$ and $J = \mathrm{Im}\bar{u}\nabla_A u$. By the current conservation $\partial_t J_0 + \nabla \cdot J = 0$.

We prove the existence of modified wave operators for the Maxwell-Schrödinger system, without any restriction on the size of those data. To this end, we solve this system with prescribed asymptotic behaviour as $t \to \infty$, defined in terms of Schrödinger and Maxwell asymptotic data. This system belongs to the borderline between the short range case and the long range one, so that the prescribed asymptotic behaviour for the Schrödinger function includes a suitable phase correction. The method consists in partially solving the Maxwell equations for the potentials, substituting the result into the Schrödinger equation, which then becomes both nonlinear and nonlocal in time. The Schrödinger function is then parametrized in terms of an amplitude and a phase satisfying a suitable auxiliary system. Then we solve the Cauchy problem for this auxiliary system by an energy method.

References

[1] J. Ginibre and G. Velo, Long range scattering and modified wave operators for the Wave-Schrödinger system, Ann. Henri Poincaré **3** (2002), 537–612.

[2] J. Ginibre and G. Velo, Long range scattering and modified wave operators for the Maxwell-Schrödinger system II. The General case, Ann. Henri Poincaeé **8** (2007), 917–994.

[3] M. Nakamura and T. Wada, Local well-posedness for the Maxwell-Schrödinger equations, Math. Ann. **332** (2005), 565–604.

[4] M. Nakamura and T. Wada, Global existence and uniqueness of solutions to the Maxwell-Schrödinger equations, Comm. Math. Phys. **276** (2007), 315–339.

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FINITE TIME BLOW-UP AND GLOBAL EXISTENCE FOR THE NONLOCAL HYPERBOLIC EQUATION

KAIQIANG ZHANG* AND BAIYU LIU

In this talk, we consider the initial boundary value problem of a hyperbolic equation with nonlocal nonlinear source on a bounded smooth domain condition:

$$\begin{cases} u_{tt} = \Delta u + (\frac{1}{|x|^{n-2}} * |u|^p)|u|^{p-2}u, & x \in \Omega, t > 0; \\ u(x,t) = 0, & x \in \partial\Omega, t > 0; \\ u(x,0) = u_0(x), u_t(x,0) = u_1(x) & x \in \Omega; \end{cases}$$

where Ω is a bounded domain in R^n,$n \geq 3$,$1 < p < (n+2)/(n-2)$. The vacuum isolation of solutions are obtained by introducing a family of potential well.

Sattinger [8] firstly studied hyperbolic equation with nonlinear source $|u|^{p-2}u$ by introducing potential well method.The potential well method help us understand under what conditions will the solution exist for all time and under what conditions will the solution become unstable to collapse. Then,by using potential well method, we obtain a threshold of global weak solution and blow up for weak solutions with low initial energy.

When blow-up occurs, the blow-up time $T_{\max}$ can't usually be computed exactly. It is therefore of great importance in practice to determine lower bounds for T_{max}. In this talk, if $u(x,t)$ blow up at time $T_{\max}$,we give a lower bound for $T_{\max}$.

References

[1] X. Li and B. Liu B, Vacuum isolating, blow up threshold and asymptotic behavior of solutions for a nonlocal parabolic equation, J. Math. Phys. **58** (2017), 101503, 9 pp.

[2] Y. Liu and R. Xu, Wave equations and reaction-diffusion equations with several nonlinear source terms of different sign, Discrete Contin. Dyn. Syst. Ser. B **7** (2007), 171–189.

[3] Y. Liu, R. Xu and T. Yu, Wave equations. and reaction-diffusion equations with several nonlinear source terms, Appl. Math. Mech. 28 (2007), 1209–1218.

[4] L.E. Payne and D.H. Sattinger, Saddle points and instability of nonlinear hyperbolic equations, Israel J. Math. **22** (1975), 273–303.

[5] G.A. Philippin, Lower bounds for blow-up time in a class of nonlinear wave equations, Z. Angew. Math. Phys. **66** (2015), 129–134.

[6] P. Pucci and J. Serrin, Some new results on global nonexistence for abstract evolution equation with positive initial energy, Topol. Methods Nonlinear Anal. **10** (1997), 241–247.

[7] P. Pucci and J. Serrin, Global nonexistence for abstract evolution equations with positive initial energy, J. Differential Equations **150** (1998), 203–214.

[8] D.H. Sattinger, On global solution of nonlinear hyperbolic equations, Arch. Ration. Mech. Anal. **30** (1968), 148–172.

[9] Y. Wang, A sufficient condition for finite time blow up of the nonlinear Klein-Gordon equations with arbitrary positive initial energy, Proc. Amer. Math. Soc. **136** (2008), 3477–3482.

[10] R. Xu, Initial boundary value problem for semilinear hyperbolic equations and parabolic equations with critical initial data, Quart. Appl. Math. **68** (2010), 459–468.

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QUANTUM INFORMATION PROCESSING BASED ON ARTIFICIAL ATOMS

HAIRUI WEI* AND FUGUO DENG

Quantum logic gates play an important role in quantum computation [1]. The precise control and manipulation of quantum states can be accomplished with quantum gates [5]. We present compact quantum circuits to deterministically implement universal quantum logic gates on different kinds of qubits via artificial atoms in optical microcavities [3, 7, 8]; Our schemes have some features. (1) The control qubits of the hybrid universal gates are encoded on the flying photons and they are excellent candidates for quantum communication, and target qubits are encoded on the solid-state electron spins in artificial atoms and they are suitable for quantum information storage and processing. (2) Compared with cross-Kerr-based or the parity-check proposals [2, 4], our schemes for optical gates do not require additional photonic qubits, which reduces quantum resources needed and decreases the errors taking place on the photonic qubits. (3) Compared with the conventional synthesis-based programs [6], our schemes for solid-state quantum gates are more compact and simpler. Our schemes could be performed with high fidelities and high efficiencies with current achievable experimental techniques.

References

[1] A. Barenco, C. H. Bennett, R. Cleve, D.P. DiVincenzo, N. Margolus, P. Shor, T. Sleator, J.A. Smolin and H. Weinfurter, Elementary gates for quantum computation, Phys. Rev. A **52** (1995), 3457–3467.

[2] C.W.J. Beenakker, D.P. DiVincenzo, C. Emary and M. Kindermann, Charge detection enables free-electron quantum computation, Phys. Rev. Lett. **93** (2004), 250501, 5 pp.

[3] J.-Z. Liu, H.-R. Wei and N.-Y. Chen, A heralded and error-rejecting three-photon hyperparallel quantum gate through cavity-assisted interactions, Sci. Rep. **8** (2018), 1885, 11 pp.

[4] K. Nemoto and W. J. Munro, Nearly deterministic linear optical controlled-NOT gate, Phys. Rev. Lett. **93** (2004), 250502.

[5] M.A. Nielsen and I.L. Chuang, Quantum Computation and Quantum Information (Cambridge University, 2000).

[6] V.V. Shende, I.L. Markov and S.S. Bullock, Minimal universal two-qubit controlled-NOT-based circuits, Phys. Rev. A **69** (2004), 062321, 8 pp.

[7] H.-R. Wei and F.-G. Deng, Universal quantum gates for hybrid systems assisted by quantum dots inside double-sided optical microcavities, Phys. Rev. A **87** (2013), 022305, 11 pp.

[8] H.-R. Wei and G.-L. Long, Universal photonic quantum gates assisted by ancilla diamond nitrogen-vacancy centers coupled to resonators, Phys. Rev. A **91** (2015), 032324.

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ANALYSIS OF TIMELINESS OF OIL PRICE NEWS INFORMATION BASED ON SVM

LUTAO ZHAO AND GUANRONG ZENG*

International oil price forecasting has always been an important and difficult issue. With the renovation of big data technology, it is a new idea to correct and improve the oil price forecasting model by collecting and extracting network news information. However, due to timeliness and other complex factors of the network news, the ability of online news to predict oil prices is unstable. In this paper, a novel method based on SVM (support vector machines) is proposed to explore the timeliness of news towards oil price. The timeliness of news can be explained by the accuracy of SVM. A multi-scale trend discovery method is proposed to more flexibly extract oil price trends at different scales and in different directions. The news texts are marked in 82 different ways. With the help of SVM, the text information is directed and extracted, and the ability of the news to describe fluctuations in oil price trends is reflected by the quality indicators of classification. The empirical results show that the new multi-scale trend discovery method has high reliability. The ability of news to describe the short-term oil price trend only lasts for about one week, and the relatively long-term trend can be maintained for two or even three weeks. News is more able to express information on relatively long-term trends. In addition, information described in the news is more likely to have an impact on the future rather than on the volatility of past oil prices. This study of the interactive relationship between news texts and oil price trends is a powerful support for the application of news texts to forecast oil prices. At the same time, it is also a powerful complement to the study of discrete correlations and interactions.

References

[1] Z. Ding, Z. Liu, Y. Zhang and R. Long, The contagion effect of international crude oil price fluctuations on Chinese stock market investor sentiment, Applied Energy 187 (2017), 27–36.

[2] G.P.C. Fung, J.X. Yu and W. Lam, News sensitive stock trend prediction, in *Advances in Knowledge Discovery and Data Mining, PAKDD 2002, Lecture Notes in Computer Science*, (eds. M.S. Chen, P.S. Yu and B. Liu) **2336**, Springer (Berlin, Heidelberg 2002), pp. 481–493.

[3] B.S. Kumar and V.Ravi, A survey of the applications of text mining in financial domain, Knowledge-Based Systems **114** (2016), 128–147.

[4] J. Li, Z. Xu, H. Xu, L. Tang and L. Yu, Forecasting oil price trends with sentiment of online news articles, Procedia Computer Sciences **91** (2016), 1081–1087.

[5] E. Panas and V. Ninni, Are oil markets chaotic? A non-linear dynamic analysis, Energy Econmics **22** (2000), 549–568.

[6] J. Wang and J. Wang, Forecasting energy market indices with recurrent neural networks: Case study of crude oil price fluctuations, Energy **102** (2016), 365–374.

[7] L. Yu, S. Wang and K.-K. Lai, A rough-set-refined text mining approach for crude oil market tendency forecasting, Inter. J. Knowledge Syst. Sci. **2** (2005), 33–46.

[8] W. Zhuang, Y. Ye, Y. Chen and T. Li, Ensemble clustering for internet security applications, IEEE Trans. Syst. Man Cybernetics **42** (2012), 1784–1796.

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INTEGRAL AVERAING TECHNIQUE FOR OSCILLATION OF SECOND-ORDER LINEAR SELF-ADJOINT DIFFERENTIAL EQUATIONS WITH IMPULSIVE EFFECT

YOSHIKI ISHIHARA* AND JITSURO SUGIE

In this talk, we consider the second-order linear self-adjoint differential equation

$$\begin{cases} (r(t)x')' + c(t)x = 0, & t \neq \theta_k, \\ \Delta(r(\theta_k)x'(\theta_k)) + b_k x(\theta_k) = 0. \end{cases} \tag{1}$$

Here, the coefficient r is a left piecewise continuously differentiable function on $[t_0, \infty)$ and $r(t) > 0$ for $t \geq t_0$; the coefficient c is a left piecewise continuous function on $[t_0, \infty)$; the sequence $\{\theta_k\}$ is strictly increasing and satisfies that $\theta_1 \geq t_0$ and θ_k tends to ∞ as $k \to \infty$; difference operator Δ is defined by $\Delta y(\theta_k) = y(\theta_k^+) - y(\theta_k^-)$; the sequence $\{d_k\}$ is a sequence of real numbers. The second part in the equation (1) is the so-called impulsive effect. Equation (1) is considered to be a model describing a motion that the movement speed of a mass point changes suddenly due to some influence.

Many researchers have studied the oscillation problem for self-adjoint differential equations without impulsive effect,

$$(r(t)x')' + c(t)x = 0. \tag{2}$$

For example, we can refer to Li [1]. The purpose of this talk is to report on how the influence is exerted on the oscillation of solutions when adding impulsive effect to equation (2). Very recently, Sugie and Ishihara [2] gave an oscilation criterion for equation (1) in the special case that $r(t) = 1$ for $t \geq t_0$.

Our results can be obtained using the ideas of Li [1] in addition to Integral averaging method and Riccati's technique. We give an example to show that the obtained result includes the oscillation criterion in [2].

References

[1] H.-J. Li, Oscillation criteria for second order linear differential equations, J. Math. Anal . Appl. **194** (1995), 217–234.

[2] J. Sugie and K. Ishihara, Philos-type oscillation criteria for linear differential equations with impulsive effect, accepted for publication in J. Math. Anal. Appl. (https://doi.org/10.1016/j.jmaa.2018.10.041)

[3] Ch.G. Philos, Oscillation theorems for linear differential equations of second order, Arch. Math. (Basel) **53** (1989), 483–492.

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FLOW AND HEAT TRANSFER OF BINGHAM PLASTIC FLUID OVER A ROTATING DISK WITH VARIABLE THICKNESS

CHUNYAN LIU*, LIANCUN ZHENG, AND PING LIN

In this talk, we consider the steady flow and heat transfer of Bingham plastic fluid over a rotating disk of finite radius with variable thickness radially in boundary layer. The boundary layer flow is caused by the rotating disk when the extra stress is greater than the yield stress of the Bingham fluid. The analyses of the velocity and temperature field related to the variable thickness disk have not been investigated in current literatures. The governing equations are first simplified into ordinary differential equations owing to the generalized Von Karman transformation for seeking solutions easily. Then semi-similarity approximate analytical solutions are obtained by using the homotopy analysis method (HAM) for different physical parameters. It is found that the Bingham number clearly influences the velocity field distribution and the skin friction coefficient C_{fr} are nonlinear growth with respect to the shape parameter m. Additionally, the effects of the involved parameters (i.e. shape parameter m, variable thickness parameter β, Reynolds number Re_v and Prandtl number Pr) on velocity and temperature distribution are investigated and analyzed in detail.

References

[1] E.C. Bingham and H. Green, Paint, A plastic material and not a viscous liquid; the measurement of its mobility and yield value, Proc. Amer. Soc. Test Mater. II (1919), 640–675.

[2] S. Liao, On the homotopy analysis method for nonlinear problems, Appl. Math. Comput. **2** (2004), 499–513.

[3] A.A. Rashaida, D.J. Bergstrom and R.J. Sumner, Mass transfer from a rotating disk to a bingham fluid, J. Appl. Mech. **1** (2006), 108–111.

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ARCWISE CONNECTED QUASICONVEX FUNCTIONS AND ITS APPLICATIONS

KAZUKI SETO* AND DAISHI KUROIWA

The minimax theorem guarantee that the max-min inequality is also an equality. Minimax theorems apply to the game theory in order for us to find solutions. The first and the most famous one was given by von Neumann [1] and Sion [2] gave a generalization of von Neumann's minimax theorem.

In this talk, we give a generalization of Sion's minimax theorem in terms of arcwise connected quasiconvex functions.

References

[1] J. v.Neumann, Zur theorie der gesellschaftsspiele, Math. Ann. **100** (1928), 295–320.
[2] M. Sion, On general minimax theorems, Pacific J. Math. **8** (1958), 171–176.
[3] H. Komiya, Elementary proof for Sion's minimax theorem, Kodai Math. J. **11** (1988), 5–7.
[4] D. Kuroiwa and K. Seto, A Sion's minimax theorem on the product of arcwise topological spaces, preprint.

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HUMAN AGE PREDICTION BASED ON DNA METHYLATION USING A GRADIENT BOOSTING REGRESSOR

XINGYAN LI* AND YAN XU

All tissues of organisms will become old as time goes on. Recent studies have shown that human aging is related to the alteration of DNA methylation in genome specific locations, and these epigenetic modifications can be used to estimate the individual age. We analyzed 16 sets of healthy samples and 9 sets of diseased samples. Six age-related CpG sites were selected through calculating Pearson correlation coefficients between age and DNA methylation values. We built a gradient boosting regressor model for these age-related CpG sites. 70% of the data was randomly selected as training data and the other 30% as independent data in each dataset for 25 runs in total. In the training dataset, the healthy samples showed that the correlation between predicted age and DNA methylation was 0.97, and the mean absolute deviation (MAD) was 2.72 years. In the independent dataset, the MAD was 4.06 years. The proposed model was further tested using the diseased samples. The MAD was 5.44 years for the training dataset and 7.08 years for the independent dataset. Furthermore, our model worked well when it was applied to saliva samples. These results illustrated that the age prediction based on six DNA methylation markers is very effective using the gradient boosting regressor.

References

[1] S.D. Din, A. Godfrey, B. Galna, S. Lord and L. Rochester, Free-living gait characteristics in ageing and Parkinson's disease: impact of environment and ambulatory bout length, J. Neuroeng. Rehabil. **13**:46 (2016), pp. 12.

[2] A. Vidaki, D. Ballard, A. Aliferi, T.H. Miller, L.P. Barron and S.D. Court, DNA methylation-based forensic age prediction using artificial neural networks and next generation sequencing, Forensic. Sci. Int. Genet. **28** (2017), 225–236.

[3] S.B. Zaghlool, M. Al-Shafai, W.A. Al Muftah, P. Kumar, M. Falchi and K. Suhre, Association of DNA methylation with age, gender, and smoking in an Arab population, Clin. Epigenetics **7** (2015), 1–12.

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CONSTRAINT QUALIFICATIONS FOR THE LAGRANGE-DUALITY OF EXTENDED REAL-VALUED CONVEX OPTIMIZATION PROBLEMS

HIROYUKI OHTANI*, KOJI OKANO*, AND DAISHI KUROIWA

In this talk, we study the following convex optimization problem:

$$\text{(P)} \quad \begin{array}{ll} \text{minimize} & f(x) \\ \text{subject to} & g_i(x) \leq 0, i = 1, 2, \ldots, m, \end{array}$$

and observe the Lagrange duality of the convex optimization problem. The Slater condition is the most famous constraint qualification for the Lagrange duality and it works when the contraint functions are extended real-valued in the setting $0 \cdot (+\infty) = +\infty$. Also it is shown that Farkas Minkowski property (FM in short) is a necessary and sufficient constraint qualification for Lagrange duality in the setting $0 \cdot (+\infty) = 0$ by Goberna, Jeyakumar and López in 2008, however FM does not contain the Slater condition. The purpose of this talk is to provide a necessary and sufficient constraint qualification for the Lagrange duality which contains the Slater condition in the setting $0 \cdot (+\infty) = +\infty$.

References

[1] V. Jeyakumar, A.M. Rubinov, B.M. Glover and Y. Ishizuka, Inequality systems and global optimization, J. Math. Anal. Appl. **202** (1996), 900–919.

[2] J.E. Martínez-Legaz and M. Volle, Duality in D.C. programming: the case of several D.C. constraints, J. Math. Anal. Appl. **237** (1999), 657–671.

[3] V. Jeyakumar, Constraint qualifications characterizing Lagrangian duality in convex optimization, J. Optim. Theory Appl. **136** (2008), 31–41.

[4] M.A. Goberna, V. Jeyakumar, M.A. López, Necessary and sufficient constraint qualifications for solvability of systems of infinite convex inequalities, Nonlinear Anal. **68** (2008), 1184–1194.

[5] R. Harada and D. Kuroiwa, Lagrange-type duality in DC programming, J. Math. Anal. Appl. **418** (2014), 415–424.

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IGLU-LYS: A PREDICTOR FOR LYSINE GLUTARYLATION THROUGH AMINO ACID PAIR ORDER FEATURES

YINGXI YANG* AND YAN XU

As one of the new posttranslational modification(PTM), lysine glutarylation has been identified in both prokaryotic and eukaryotic cells. These glutarylated proteins are involved in various cellular functions such as translation, metabolism and exhibited diverse subcellular localizations. Experimental identification of lysine glutarylation sites was in 2014 and also found its deglutarylase sirturn 5(SIRT 5). Computational prediction of lysine glutarylation could be a complementary way to the experimental technique. In this work the lysine glutarylation predictor iGlu-Lys has been developed based on machine learning scheme. We have selected the best feature scheme which took the amino acid pair order and special-position information into account from four constructions. Machine learning algorithm support vector machine (SVM) has been adopted and its performance has been measured for different window length of peptides. In the 10-fold cross-validation with window length 19 the AUC and MCC were 0.8944 and 0.5098, respectively. Different ROC curves in 6-, 8-, and 10-fold cross-validations were very close which illustrated the robustness of our predictor. The results of iGLu-Lys were better than the existing method GlutPred. Meanwhile, a free webserver for iGlu-Lys is accessible at http://app.aporc.org/iGlu-Lys/.

References

[1] W. Deng, Y. Wang, L. Ma, Y. Zhang, et al., Computational prediction of methylation types of covalently modified lysine and arginine residues in proteins, Brief Bioinform. **18** (2017), 647–658.

[2] Y. Du, Z. Zhai, Y. Li, M. Lu, et al., Prediction of protein lysine acylation by integrating primary sequence information with multiple functional features, J. Proteome Res. **15** (2016), 4234–4244.

[3] Z. Ju, J.-Z. Cao and H. Gu, Predicting lysine phosphoglycerylation with fuzzy SVM by incorporating k-spaced amino acid pairs into Chou's general PseAAC, J. Theor. Biol. **397** (2016), 145–150.

[4] Z. Ju and J.-J. He, Prediction of lysine glutarylation sites by maximum relevance minimum redundancy feature selection, Anal. Biochem. **550** (2018), 1–7.

[5] Y. Xu, Y.-X. Ding, J. Ding, L.-Y. Wu and Y. Xue, Mal-Lys: prediction of lysine malonylation sites in proteins integrated sequence-based features with mRMR feature selection, Sci Rep. **6** (2016), 38318, 7 pp.

[6] Z. Ju and J.-J. He, Prediction of lysine glutarylation sites by maximum relevance minimum redundancy feature selection, Anal. Biochem. **550** (2018), 1–7.

[7] Q. Zhao, Y. Xie, Y. Zheng, S. Jiang, et al, GPS-SUMO: a tool for the prediction of sumoylation sites and SUMO-interaction motifs, Nucleic Acids Res. **42** (2014), W325–W330.

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CONSTRAINT QUALIFICATIONS FOR A LAGRANGE-TYPE DUALITY OF EXTENDED REAL-VALUED DC OPTIMIZATION PROBLEMS

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We study the following optimization problem:

$$\text{(P)} \quad \begin{array}{ll} \text{minimize} & f_0(x) - g_0(x) \\ \text{subject to} & f_i(x) - g_i(x) \leq 0, i = 1, 2, \ldots, m, \end{array}$$

where $f_0, g_0 : \mathbb{R}^n \to \mathbb{R}$, $f_i, g_i : \mathbb{R}^n \to \mathbb{R} \cup \{+\infty\}$ are convex functions for all $i = 1, 2, \ldots, m$. In the previous result in [**?**], a constraint qualification for a Lagrange-type duality of the optimization problem (P) was given when all constraint functions are real-valued, and the constraint qualification does not work when these functions are extended real-valued. The purpose of the talk is to give another constraint qualification for the Lagrange-type duality of the optimization problem (P) whose constraint functions are extended real-valued in the case $0 \cdot (+\infty) = +\infty$.

References

[1] V. Jeyakumar, A.M. Rubinov, B.M. Glover and Y. Ishizuka, Inequality systems and global optimization. J. Math. Anal. Appl. **202** (1996), 900–919.

[2] J.E. Martínez-Legaz and M. Volle, Duality in DC programming: the case of several DC constraints, J. Math. Anal. Appl. **237** (1999), 657–671.

[3] M.A. Goberna, V. Jeyakumar and M.A. López, Necessary and sufficient constraint qualifications for solvability of systems of infinite convex inequalities, Nonlinear Anal. **68** (2008), 1184–1194.

[4] R. Harada and D. Kuroiwa, Lagrange-type duality in DC programming, J. Math. Anal. Appl. **418** (2014), 415–424.

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