บันทึกข้อความ

สำนักงาน มหาวิทยาลัยหอการค้าไทย ถนนรัชดาภิเษก มหาวิทยาลัยหอการค้าไทย 33/45
ที่ 1 0529.81 / 150 วันที่ 15 กุมภาพันธ์ 2560

เรื่อง ขออนุมัติเงินสนับสนุนเพื่อนำเสนอผลงานวิจัยในการประชุมวิชาการระดับนานาชาติในต่างประเทศ

เรียน รองคณบดีฝ่ายวิจัยและบริการวิชาการ ผ่านนวิบางกว้างวิจัย

ตามที่เข้าพัก ดร.รัชดา โสภาพัฒน์ เลขานุการ ได้รับการตกลงรับในการนำเสนองานวิจัยเรื่อง A Constitutive Model of Ligaments and Tendons Accounting for Fiber-Matrix Interaction in the Biomechanics and Biomedical Engineering ระหว่างวันที่ 14 – 15 พฤษภาคม 2560 ณ ประเทศแคนาดา นั้น

ดังนั้น เพื่อให้การนำเสนอผลงานวิจัยเป็นไปด้วยความเรียบร้อย จึงขอร้องให้อนุมัติเงินสนับสนุนเพื่อนำเสนองานวิจัยดังกล่าว เป็นจำนวนเงิน 40,000 บาท (สี่หมื่นบาทถ้วน) โดยมีรายละเอียดในการนำเสนอผลงาน ทั้งสิ้น 92,380 บาท (-กับหนังสือพิมพ์รายละเอียดสินค้าและบริการ) ดังนี้

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14-ก.ค.2560
Dr. Ratchada Sopakayang
Ubon Ratchathani University
Thailand

Herewith, the international scientific committee is happy to inform you that the peer-reviewed draft paper code 17NL050379 entitled (A Constitutive Model of Ligaments and Tendons Accounting for Fiber-Matrix Interaction by Ratchada Sopakayang, Gerhard A. Holzapfel) has been accepted for oral presentation as well as inclusion in the conference proceedings of the ICBBE 2017: 19th International Conference on Biomechanics and Biomedical Engineering to be held in Amsterdam, The Netherlands during May, 14-15, 2017. The high-impact conference papers will also be considered for publication in the special journal issues at http://waset.org/Publications.

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A Constitutive Model of Ligaments and Tendons Accounting for Fiber-Matrix Interaction

Ratchada Sopakayang and Gerhard A. Holzapfel

Abstract—In this study, a new constitutive model is developed to describe the hyperelastic behavior of collagenous tissues with a parallel arrangement of collagen fibers such as ligaments and tendons. The model is formulated using a continuum approach incorporating the structural changes of the main tissue components: collagen fibers, proteoglycan-rich matrix and fiber-matrix interaction. The mechanical contribution of the interaction between the fibers and the matrix is simply expressed by a coupling term. The structural change of the collagen fibers is incorporated in the constitutive model to describe the activation of the fibers under tissue straining. Finally, the constitutive model can easily describe the stress-stretch nonlinearity which occurs when a ligament/tendon is axially stretched. This study shows that the interaction between the fibers and the matrix contributes to a better understanding of the physiological mechanisms of ligaments and tendons under axial loading.

Index Terms—Hyperelasticity, constitutive model, fiber-matrix interaction, ligament, tendon.

I. INTRODUCTION

The purpose of this work is to develop a simple constitutive model that can describe the hyperelastic behavior of ligaments and tendons. In previous studies, phenomenological and structural models of ligaments and tendons have been formulated by accounting for the physiology of their main structural components, i.e. collagen fibers and proteoglycan-rich matrix [8,10]. These models are not considering one important contributor to the mechanical behavior of ligaments and tendons which is the interaction between the fibers and the matrix. The fiber-matrix interaction has been identified that it plays a significant role on the elastic and viscoelastic properties of ligaments and tendons [2,5] and other tissues [1,3,7]. Although some previous works incorporated the interaction into their models [2,5], the mechanism of the coupling between the fibers and the matrix is still unclear and need more advanced studies. Therefore, in the present work, we develop a new mathematical model of ligaments and tendons for describing the tensile response. The model is formulated by using a continuum approach incorporating the structural changes of their main components: the fibers, the matrix and the fiber-matrix interaction. The specification of the work is described here as follows.

II. MATHEMATICAL FORMULATION

A. Strain-Energy Function

The strain-energy function is assumed to be composed of three components which are based on the main structure of the tissues and their mechanisms. Therefore, the strain-energy function of ligaments and tendons, say \( W \), are generated from the contributions originating from the collagen fibers, the matrix and the fiber-matrix interaction. Thus,

\[
W = \Psi_M(I_1) + P(I_4)\Psi_F(I_4) + (1 - P(I_4))\Psi_{FM}(I_1, I_4),
\]

where \( \Psi_M \) is the energy stored in the matrix, \( \Psi_F \) is that of the fibers, \( \Psi_{FM} \) is the strain energy of the fiber-matrix interaction and \( P(I_4) \) is the cumulative density function of the stretched fibers. In addition, \( I_1 \) is the first invariant of the right Cauchy-Green tensor \( C \) and \( I_4 = C : a_0 \otimes a_0 \) is the fourth invariant of \( C \) and \( a_0 \), where \( a_0 \) describes the direction of the collagen fibers in the reference configuration, see, e.g., [4].

The matrix is assumed to behave according to a neo-Hookean material so that

\[
\Psi_M(I_1) = \frac{\mu}{2}(I_1 - 3),
\]

where \( \mu \) is the shear modulus. The mechanical response of the fibers is modeled as

\[
\Psi_F(I_4) = k(I_4 - 1)^2,
\]

where \( k \) is a material parameter. The mechanical contribution of the interaction between the fibers and the matrix is modeled as

\[
\Psi_{FM}(I_1, I_4) = \frac{\mu}{2}k(I_1 - 3)(I_4 - 1)^2.
\]

The collagen fibers are assumed to become straight at different stretches \( \lambda_0 \geq 1 \), defined by the Weibull probability density function [8,10], i.e.

\[
p(\lambda_0) = \frac{\alpha}{\beta} \left( \frac{\lambda_0 - 1}{\beta} \right)^{\alpha - 1} \exp\left\{ -\left( \frac{\lambda_0 - 1}{\beta} \right)^\alpha \right\},
\]

where \( \alpha > 0 \) is the so-called shape parameter and \( \beta > 0 \) is the so-called scale parameter. Therefore, the cumulative density function \( P \) of the stretched fibers follows with (5)

\[
P(I_4) = \int_1^{I_4} p(\lambda_0) d\lambda_0 = 1 - \exp\left\{ -\left( \frac{I_4 - 1}{\beta} \right)^\alpha \right\}.
\]

Finally, the strain-energy function (1) of the tissue can be rewritten as

\[
W = \frac{\mu}{2}(I_1 - 3) + (1 - \exp\left\{ -\left( \frac{I_4 - 1}{\beta} \right)^\alpha \right\})k(I_4 - 1)^2
+ \exp\left\{ -\left( \frac{I_4 - 1}{\beta} \right)^\alpha \right\} \frac{\mu}{2}k(I_1 - 3)(I_4 - 1)^2.
\]
B. Cauchy Stress Tensor

Ligaments and tendons are classified as anisotropic mate­rial with one family of collagen fibers. Therefore, by (just) considering the invariants hand 1

\[ T = 2(W_1 B + W_4 a \otimes a) - 3I. \] (8)

where \( B \) is the left Cauchy–Green tensor, \( I \) denotes the second­order unit tensor and \( p \) is an indeterminate Lagrange multiplier which can be identified as a hydrostatic pressure [4]. In addition, in (8) \( a = Fa_0 \) denotes the fiber direction in the deformed configuration, and \( F \) is the deformation gradient. By recalling the strain-energy function \( W \), the differentiation of \( W \) can be written as

\[ W_1 = \frac{\partial W}{\partial I_1} = \frac{\mu}{2} + \frac{\mu}{2} k(I_4 - 1)^2 \exp\left\{-\frac{[I_4 - 1]/\beta}{\alpha}\right\}, \] \( W_4 = \frac{\partial W}{\partial I_4} = 2k(I_4 - 1) \]

\[ + 2k\left[(I_4 - 1)\exp\left\{-\frac{[I_4 - 1]/\beta}{\alpha}\right\}\right] \frac{\mu}{2}(I_4 - 3) - 1 \]

\[ - \frac{\alpha}{2} \left(\frac{I_4 - 1}{\beta}\right)^{\alpha} + \frac{\mu}{4}(I_4 - 1) \left(\frac{I_4 - 1}{\beta}\right)^{\alpha}. \] (10)

In this study we focus on the description of the tensile response. We assume that the tensile loading, i.e. \( \lambda \), is applied to the specimen in the \( x \)-direction which is also assumed to be the fiber direction, while \( x_1 \) and \( x_2 \) are the transverse directions. Therefore, \( F \) takes on the matrix form

\[ [F] = \begin{bmatrix} \lambda_1 & 0 & 0 \\ 0 & \lambda_2 & 0 \\ 0 & 0 & \lambda \end{bmatrix}. \] (11)

The tissue is assumed to be an incompressible material, therefore the incompressibility constraint must be satisfied, i.e.

\[ \det(F) = \lambda_1 \lambda_2 \lambda = 1. \] (12)

We then obtain

\[ \lambda_1 = \lambda_2 = \frac{1}{\sqrt{\lambda}}. \] (13)

Then, the left Cauchy–Green tensor \( B \) takes on the following matrix form

\[ [B] = [F][F^T] = \begin{bmatrix} \lambda^2_1 & 0 & 0 \\ 0 & \lambda^2_2 & 0 \\ 0 & 0 & \lambda^2 \end{bmatrix}, \] (14)

while the identity tensor has the matrix form

\[ [I] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}. \] (15)

In the undeformed configuration, the unit fiber orientation vector is

\[ [a_0] = \begin{bmatrix} 0 & 0 & 1 \end{bmatrix}^T. \] (16)

Since the deformed fiber direction \( a \) is related to the undeformed direction \( a_0 \) according to \( [a] = [F][a_0] \), we obtain the structure tensor \( a \otimes a \) in the matrix form as

\[ [a \otimes a] = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & \lambda^2 \end{bmatrix}. \] (17)

The invariants can then be expressed as

\[ I_1 = \text{tr}[B] = \lambda^2_1 + \lambda^2_2 + \lambda^2 = \frac{2}{\lambda} + \lambda^2, \] \( I_4 = [a_0] \cdot [B][a_0] = \lambda^2. \] (19)

By substituting Eqs. (13)-(15), (17) and (19) into (8), we obtain the matrix

\[ [T] = \begin{bmatrix} W_1 - p & 0 & 0 \\ 0 & \frac{1}{2}W_1 - p & 0 \\ 0 & 0 & 2\lambda^2 W_3 + 2\lambda^4 W_4 - p \end{bmatrix}. \] (20)

The boundary condition of the problem is

\[ T_{11} = T_{22} = 0. \] (21)

By applying this boundary condition to the Cauchy stress matrix \([T]\) in (20), we can then find the Lagrange multiplier \( p \) as

\[ p = \frac{2}{\lambda} W_1 = \frac{\mu}{\lambda} + \frac{\mu}{4}k(I_4 - 1)^2 \exp\left\{-\frac{[I_4 - 1]/\beta}{\alpha}\right\}. \] (22)

where (9) has been used. By substituting \( p \) into \( T_{33} \) of Eq. (20), we then obtain

\[ T_{33} = \lambda \mu^2 - \frac{\mu}{\lambda} + 4\lambda^4 (I_4 - 1) \]

\[ + 4\lambda^4 (I_4 - 1) \exp\left\{-\frac{[I_4 - 1]/\beta}{\alpha}\right\} \frac{\mu}{2}(I_4 - 3) - 1 + \frac{\alpha}{2} \frac{\mu}{2}(I_4 - 1) \alpha \]

\[ - \frac{\alpha}{2} \left(\frac{I_4 - 1}{\beta}\right)^{\alpha} + \frac{\mu}{4\lambda^2}(I_4 - 1) \left(\frac{I_4 - 1}{\beta}\right)^{\alpha} \]

\[ + \frac{\mu}{4\lambda^2}(I_4 - 1) \left(\frac{I_4 - 1}{\beta}\right)^{\alpha}. \] (23)

where (9) and (10) have been used.

Finally, we substitute the expression of the invariants from Eqs. (18) and (19) into \( T_{33} \), then we find an explicit relationship between the Cauchy stress \( T_{33} \) and the stretch \( \lambda \) of the tissue as

\[ T_{33} = \lambda \mu^2 - \frac{\mu}{\lambda} + 4\lambda^4 (\lambda^2 - 1) \]

\[ + 4\lambda^4 (\lambda^2 - 1) \exp\left\{-\frac{[(\lambda^2 - 1)/\beta]}{\alpha}\right\} \frac{\mu}{\lambda} + \frac{\alpha}{2} \frac{\mu}{2}(\lambda^2 - 1) \alpha \]

\[ - \frac{\alpha}{2} \left(\frac{\lambda^2 + \lambda^2 - 3}{\beta}\right)^{\alpha} + \frac{\mu}{4\lambda^2}(\lambda^2 - 1) \left(\frac{\lambda^2 + \lambda^2 - 1}{\beta}\right)^{\alpha}. \] (24)

III. Results

A. Parameter Estimation

There are four parameters in the model, i.e. \( \mu, k, \alpha, \beta \), requiring an estimation in order to describe the tensile behavior of ligaments and tendons. In general all parameters in the model can be found by curve fitting the model to the tensile data. Because of the lack of some experimental results in the published papers [2,6], a complete set of parameters obtained by the curve fitting could not be found. The appropriate values of parameters for any specific type of ligaments and tendons can usually be found by validating the model with the experimental data of some specific tests.
For this work, in order to demonstrate the ability of the proposed model in describing the tensile behavior of ligaments and tendons, the values of the parameters $J_L$ and $k$ are assumed to be fixed values of 1 MPa. Then, the model is curve fitted with the tensile experimental data of sheep flexor tendons, as documented in [2,6]. Hence, the rest of the parameters are estimated from the curve fitting, and are $\alpha = 1.431$ and $\beta = 0.143$ with $R^2 = 0.9913$. As shown in Fig. 1, the model has a good fit with the experimental data and can describe the mechanical characterization under tension quite well.

![Fig. 1. Nonlinear elastic Cauchy stress-stretch data describing the tensile behavior of a sheep flexor tendon, and model fit with parameters $\mu = k = 1$ MPa, $\alpha = 1.431$ and $\beta = 0.143$ ($R^2 = 0.9913$).](image)

**B. Influence of Model Parameters**

The influence of the model parameters on the tensile response was studied by varying the parameters as shown in Figs 2-5. Thereby, each material parameter was varied individually, while the remaining parameters were fixed by the original values obtained by curve fitting of the proposed model to the published stress-strain data [2,6]. The Figs 2 and 3 illustrate the influence of the parameters $\mu$ and $k$ on the characteristic tensile behavior, respectively. As shown in Fig. 2, an increase of $\mu$ causes an increase of the modulus of the ligaments/tendons over the stretch in every stretch region of the tensile behavior. In a similar way, an increase of $k$ leads to an increase of the modulus of the tissues over the stretch, but not so much at the lower stretch domain, as shown in Fig. 3. At the low stretch region of the tensile behavior, the different values of $k$ do not affect the tensile behavior but they play a significant role at the higher stretch domain.

The effects of the shape parameter $\alpha$, and the scale parameter $\beta$ of the Weibull probability density function that described the characteristic of the recruitment of collagen fibers are presented in Figs 4 and 5, respectively. As can be seen from Fig. 4, for smaller values of $\alpha$, the relationship between the Cauchy stress and the stretch of ligaments/tendons show less nonlinearity. For larger values of $\alpha$, the curves show more nonlinearity of the modulus of the tissue influenced by the recruitment of fibers. However, the values of the stress of the tissues over stretch for each $\alpha$ are not much different. Therefore, $\alpha$ can mainly influence the nonlinearity of the modulus of the tissue but it does not play the role to increase the modulus over stretch. In another way, the scale parameter $\beta$ influences both the nonlinearity and the change in the modulus over stretch, as shown in Fig. 5. For larger values of $\beta$, the stress-strain curve of the tissue shows less nonlinearity, and smaller values of modulus of the tissues over stretch.

![Fig. 2. Influence of the parameter $\mu$ (relating to the matrix) on the tensile behavior.](image)

![Fig. 3. Influence of the parameter $k$ (relating to the collagen fibers) on the tensile behavior.](image)

![Fig. 4. Influence of the shape parameter $\alpha$ (relating to the Weibull probability density function) on the tensile behavior.](image)

![Fig. 5. Influence of the scale parameter $\beta$ (relating to the Weibull probability density function) on the tensile behavior.](image)
IV. DISCUSSION AND CONCLUSION

A new mathematical model is presented to describe the nonlinear elastic behavior of ligaments and tendons under tensile loading. This mathematical model is formulated by accounting for the mechanical contribution of the main structural units of ligaments and tendons, i.e. the collagen fibers, the matrix and the fiber-matrix interaction. The model has four parameters \((\mu, k, \alpha, \beta)\) representing the mechanical characteristic of the internal structure of the tissue. The parameters \(\mu\) and \(k\) are related to the matrix and the collagen fibers, respectively, while the progression of the fiber recruitment is captured by the Weibull probability distribution function equipped with the shape parameter \(\alpha\) and the scale parameter \(\beta\). According to the results section, it can be seen that the model can describe the typical characteristic of the tensile behavior of ligaments and tendons very well. The curve fitting of the model and the experimental data obtained from the published papers \([2,6]\) is presented in Fig. 1 with \(R^2 \approx 0.9913\). The study of the parameter variation shows that \(\mu\) and \(k\) control the level of the values of the modulus of ligaments and tendons, as shown in Figs 2 and 3, respectively, while \(\alpha\) and \(\beta\) play a role on the nonlinearity of the modulus of the tissue in the tensile characterization, as shown in Figs 4 and 5, respectively. The model simulations in Figs 2 and 3 indicate that in a very small stretch region of the tensile behavior, only the matrix is active and responsible for load bearing, while the collagen fibers are embedded in the matrix and still wavy. Therefore, the wavy collagen fibers may move along the matrix at the beginning of the loading but cannot bear the load. The model suggests that only the matrix plays the role of the load bearing element in the very low stretch domain, while in the larger stretch region both collagen fibers and the matrix are load bearing.

In conclusion, a new constitutive model was proposed able to describe the mechanical response of ligaments and tendons under tension. The information about the orientation of the collagen fibers was incorporated into the continuum model, and the nonlinearity of the elastic behavior of the tissue could be demonstrated. The work has shown a simple and straightforward way to formulate an explicit relationship between the Cauchy stress and the stretch \(\lambda\) of the tissue. Certainly, we need more detailed (experimental) information about the fiber-matrix interaction of ligaments and tendons which would be very valuable for refined modeling. The model can easily be extended to describe other connective tissues or other hyperelastic materials with more fiber families and fiber dispersion. The model can also be extended to describe a viscoelastic response such as creep and relaxation along with the related hysteresis which for many materials such as soft tissues, rubbers and polymers is required.

ACKNOWLEDGMENT

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REFERENCES

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The ICBBE 2017: 19th International Conference on Biomechanics and Biomedical Engineering aims to bring together leading academic scientists, researchers and research scholars to exchange and share their experiences and research results on all aspects of Biomechanics and Biomedical Engineering. It also provides a premier interdisciplinary platform for researchers, practitioners and educators to present and discuss the most recent innovations, trends, and concerns as well as practical challenges encountered and solutions adopted in the fields of Biomechanics and Biomedical Engineering.

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2) Comparative Analysis between Corn and Ramon (Bromus Alleghaniensis) Starches to Be Used as Sustainable Bio-Based Plastics
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   Ramon Sancibrian, Carlos Redondo-Figueroa, Maria C. Gutiérrez-Diez, Esther G. Sarabia, Maria A. Benito-Gonzalez, Jose C. Manuel-Palazuelos

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1 Oral Qi Wang
The Chinese University of Hong Kong Hong Kong
Target Training on Chinese As a Tonal Language for Better Communication

2 Oral Kalayanee Senasu
National Institute of Development Administration Thailand
Happiness Levels and Factors Affect Happiness in Thailand: a Comparative Study of 4 Periods

3 Oral Mikko Hänninen
Aalto University School of Business Finland
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Conference Venue
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Nutan Kaushik, Daya Bharadwaj
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Contribution of Nlrp3 Inflammasome to the Protective Effect of 5,14-hedge, a 20-hete Mimetic, Against Lps-induced Septic Shock in Rats

Mersin University Turkey

Protective Effect of Bexarotene, a Selective Rxa Agonist, Against Hypertension Associated With Inflammation and Tissue Injury Linked to Decreased Circulating Inos Levels in a Rat Model of Septic Shock

Bahr Tuncatan, Sefika Pinar Kucukavruk, Meryem Temiz-resitoğlu, Demet Sinem Guden, Ayse Nihal Sarı, Seyhan Sahin-frat
Mersin University Turkey

Role of the Histamine H3-receptor in Scorpion Venom Induced Hepatorenal Inflammatory Injuries

Amal Megdad-Iamraou, Sonia Adi-bessalem, Fatima Laraba-djebali
University of Sciences and Technology Houari Boumedienne Algeria

Beneficial Effects of Histamine H4 Receptor Antagonist Associated to Immunotherapy in the Treatment of Inflammatory Response Induced by Scorpion Venom

Amal Megdad-Iamraou, Sonia Adi-bessalem, Amina Siff, Fatima Laraba-djebali
University of Sciences and Technology Houari Boumedienne Algeria

Novel Molecular Mechanisms Involved in Macrophage Phenotypic Polarization

Mani Srivastava, Uzma Saqib, Adnan Naim, Arjali Roy, Dongfeng Liu, Deepak Bhattacharjee, Ravinder Ravinder, Mirza S. Balg
Indian Institute of Technology India

Simultaneous Targeting of Myd88 and Nur77 As an Effective Approach for the Treatment of Inflammatory Diseases

Uzma Saqib, Mirza S Balg
IIIT India

The Effect of Organizational Justice on Management by Values Perception and Intention to Leave: a Study Among Nurses

Arzu K. Harmandi Seren, Burcu Alacan, Serap Attuntas, Ulu Baykal
Istanbul University Turkey
A Qualitative Study: Determination of the Working Conditions and Knowledge Levels of Oncology Nurses in Terms of Employee Safety
Rujnan Tuna, Ulku Baykal
Istanbul Medeniyet University Turkey

Efficacy of Single-dose Azithromycin Therapy for the Treatment of Chlamydia Trachomatis in Patients Evaluated for Child Sexual Abuse in an Urban Health Center 2006-16
Trenton Hubbard, Kenneth Soyeml, Emily Siffermann
John H. Stroger Jr. Hospital of Cook County United States

An Examination of External and Internal Factors Leading to world Class Swim-coaching Performances: a Qualitative Study
Earl McCarthy
University College Dublin Ireland

Effect of Three Month Aerobic Interval Training on Some of Mitochondrial Apoptotic Gene Expression in Rat Skeletal Muscle
Masoud Asgharpour-arshad, Marefat Siahkohian, Lotfali Bolboli, Afshar Jafari, Farzam Sheykzadeh Hesari, Leila Sattarzadeh
Amin Police University Iran, Islamic Republic Of

Neighborhood Characteristics and Cognitive Function In Older Adults in Hong Kong: Where You Live Make a Difference
Yingqi Guo, Geoff Chan, Paul Yip
The University of Hong Kong Hong Kong

Integrating Geographic Information Into Diabetes Disease Management
Tair-junn Cheng, Tsu-yun Chiu, Tsung-hsueh Lu
Chi-mei Hospital Taiwan

Exploring the Spatial Characteristics of Mortality Map: a Statistical Area Perspective
Jung-hong Hong, Jing-chen Yang, Cai-yu Ou
National Cheng Kung University Taiwan

SESSION 13
Chair: Tsung-Hsueh (Robert) Lu

Bringing the Confidence Intervals Into Choropleth Mortality Map
Tzu-Jung Tseng, Pel-hsuen Han, Tsung-hsueh Lu
National Cheng Kung University Taiwan

Assessing the Accessibility to Primary Percutaneous Coronary Intervention
Tzu-Jung Tseng, Pel-hsuen Han, Tsung-hsueh Lu
National Cheng Kung University Taiwan

Rural to Urban Migration and Mental Health Consequences in Urbanizing China
Jie Li, Nick Manning
King's College London United Kingdom

SESSION 14
Chair: Gloria Blanco-Lizana

Harnessing Environmental Dna to Assess the Environmental Sustainability of Commercial Shellfish Aquaculture in the Pacific Northwest United States
James Kralj
University of Washington United States

Searching SnpS Variants in Myod-1 and Myod-2 Genes Linked to Body Weight in Gilthead Seabream, Sparus Aurata L.
Universidad De Oviedo Spain

Urban Transformation In the Context of Urban Pattern and Socioeconomic Discourse
Irem Bayraktar, Cemre Yaz Demircioğlu
Çeşme University Turkey

Cultural Diversity and Minorities in Jordan: Preserving Minorities' Heritage and the Impact on Jordanian Architecture, Case Study: Jabal Alashrafieh
Jawad Gousous, Muhammad Al-absl
Al-zaytoonah University of Jordan Jordan

A Case Study of Building Behavior Damaged During 26th Oct, 2015 Earthquake In Northern Areas of Pakistan
Rahmat Ali, Amjad Naseer, Abad A. Shah
Sarhad University of Science and Information Technology Pakistan

An Eulerian Method for Fluid-structure Interaction Simulation Applied to Wave Damping by Elastic Structures
Deborde Julien, Milcent Thomas, Glookner Stéphane, Lubin Pierre
University of Bordeaux France

Scaling of Macroscopic Superpositions Close to a Quantum Phase Transition
Tahereh Abad, Vahld Karlmlpour
Sharif University of Technology Iran, Islamic Republic Of

Ps@e Based Modelling, Simulation and Synchronous Interconnection of Eastern Grid and North-eastern Regional Grid of India
Toushlk Maltl, Salbal Chatterjee, Kamallyoti Gogol, Arijlt Basuray
North Eastern Regional Institute of Science and Technology India

Study of Transformer and Motor Winding Under Pulsed Power Application
Arijl Basuray, Salbal Chatterjee
Neo Tele-tronix Private Limited India

Radar Cross Section Modelling of Lossy Dielectrics
Clara Plenaar, J.W. Odendaal, J. Joubert, J. C. Smit
University of Pretoria South Africa

Validation of Asymptotic Techniques to Predict Bistatic Radar Cross Section
M. Pienaar, J. W. Odendaal, J. C. Smit, J. Joubert
University of Pretoria South Africa
MULTIMODAL, GAME-BASED AND MOBILE LEARNING PRACTICES IN SWEDISH SCHOOLS TRIGGERED BY TABLETS
Jalal Nouri, Terese Sundman, Teresa Cerrato-pargman
Stockholm University Sweden

LEARNERS LEFT TO THEIR OWN DEVICES: THE CHALLENGES OF STUDENT SCAFFOLDING IN OUTDOORS MOBILE LEARNING ACTIVITIES
Karvan Zetali, Jalal Nouri
Stockholm University Sweden

CHATBOTS VS. WEBSITES: A COMPARATIVE ANALYSIS MEASURING USER EXPERIENCE AND EMOTIONS IN MOBILE COMMERCE
Stephan Boehm, Julia Engel, Judith Elsser
Rheinmain University of Applied Sciences Germany

PUBLIC HEALTH EDUCATION IN THE UNITED STATES: RESPONSE TO CLIMATE CHANGE
Gary S. Silverman
University of North Carolina United States

THE EFFECTS OF NORTH SEA CASPIAN PATTERN INDEX (ncpi) ON THE TEMPERATURE AND PRECIPITATION REGIME IN AEGEAN REGION OF TURKEY
Cenik Sezen, Turgay Partal
Ondokuz Mayis University Turkey

CARBON DIOXIDE TOXICITY AND CLIMATE CHANGE: A MAJOR UNAPPREHENDED RISK FOR HUMAN HEALTH
Philip Bienwith
Australian National University Australia

EXPERIMENT ON ARTIFICIAL RECHARGE OF GROUNDWATER IMPLEMENTED PROJECT: EFFECT ON THE INFILTRATION VELOCITY BY VEGETATION MULCH
Cheh-shyh Ting, Jinn-liang Lin
National Pingtung University of Science and Technology Taiwan

SESSION 15
Chair: Alaa Younls

UNLOCKING TRANSFORMATIONAL RESILIENCE IN THE AFTERMATH OF A FLOOD DISASTER. A CASE STUDY FROM CUMBRIA.
Kate Crinion, Stanley Mcgreal, Martin Haran, David McHillaton
Ulster University Ireland

HEAVY METAL CONTAMINATION AND ENVIRONMENTAL RISK IN SURFACE SEDIMENTS ALONG THE COASTS OF SUEZ AND AQABA GULFS, EGYPT
Alaa M. Younls, Ismail S. Ismail, Lamiaa I. Mohamedein, Shimaal F. Ahmed
Suez University Egypt

ANALYSIS OF PERFORATED SKIRTED FOUNDATION
Rahul Kolate, Yashwant Kolekar
College of Engineering, Pune India

TOWARDS AN AESTHETIC OF ONLINE VIDEO
Bernando Palau Cabrera
University of Los Andes Chile

PROGRAM GUIDELINES
1. GUIDE FOR ORAL AND E-POSTER PRESENTATIONS

We kindly ask ORAL presenters to prepare electronic presentations of 15 minutes (allowing 5 minutes for discussions) and e-POSTER presenters to prepare short electronic presentations of 5 minutes (allowing 5 minutes for discussions) (NO PRINT OUTS). A Linux-based operating system is used for both Oral and e-Poster presentations. All presenters should make a PDF file version of their presentation and upload it to the system.

2. PRESENTATION SET UP

Laptop Computer, Projector, USB Flash Drive (No CD Drive), MS. PowerPoint/AcrobatReader

3. SYSTEM SECURITY ALERT

As many delegates insert their USB devices into the laptop computer provided for the presentations, we cannot avoid Cyber/Computer viruses. You are kindly advised to bring a USB Flash Drive containing ONLY your .ppt, .ptx or .pdf presentation file or risk other files being corrupted or made permanently inaccessible.

4. ROLE OF THE SESSION CHAIR

The duties of the Session Chair include the following:

1. Arrive at the conference hall at least 10 minutes before the session begins. Identify the paper presenters and discussant(s) in advance, and introduce yourself. Remind each presenter of the time limits that apply, and describe the method that you will use to alert them of time limits during the actual presentation.

2. At the start of the session, introduce yourself to the audience, announce the session/title, and offer a brief overview indicating how the papers are related.

3. Prior to each presentation, introduce the speaker, announce the paper's title, the name(s) of the author(s), and provide brief comments regarding the affiliation and/or background of each presenter. Identify the individual who will be speaking if it is someone other than the first author.

4. During the presentations enforce time limits strictly so that no author (or audience member) monopolizes someone else's time. Oral paper presentations each have 20 minutes (15 minutes for full presentation papers, 5 minutes for discussions), and 10 minutes for e-Poster (electronic poster) presentations (5 minutes for poster presentation, 5 minutes for discussions).

5. Once presentations are complete (oral paper presentations and e-Poster presentations), the remaining time can be used for informal discussion between the audience and session participants. It is your job to field questions from the audience.

6. Try to conduct the session as informally as possible (e.g., use first names when addressing participants and members of the audience) to encourage as much audience participation as possible.

5. BEST PAPER AWARDS / BEST PRESENTATION AWARDS

A Best Paper Award / Best Presentation Award will be conferred on the author(s) of an abstract or a full paper presented at the conference. Selection is made based on the best combined marks of the abstract / paper review and presentation quality appraisal.
conducted by the Session Chair at the conference venue, and assessed by the Program Committee. Award winners will be announced after the conference. The author(s) of a selected paper/presentation will receive a signed and stamped official Best Paper Award / Best Presentation Award e-certificate.