Innovation Grant Application Form

Before completing the following application, carefully review the 'Guidelines and Information' and 'Application Checklist' documents at www.horsesandhumans.org.

A complete application packet includes:

I. Cover Page
II. Scientific Abstract
III. Need/Justification
IV. Research Narrative
V. Proposed Time Line
VI. Intent to Publish
VII. Proposed Budget
VIII. Lay-language Abstract
IX. Biographical Sketch of Principal Investigator
X. Evidence of Compliance with Government Requirements
XI. Signed 'Conditions of Award' Form
XII. Attachments

Please no binding or stapling of materials. Incomplete applications will not be considered. Applications lacking any of the required materials are considered incomplete.

Applicants are required to use correct equine-assisted activities/therapies (EAA/T) terminology (available at horsesandhumans.org).

APPLICATIONS MUST BE SUBMITTED IN BOTH PAPER AND ELECTRONIC FORMATS. Email the completed application to info@horsesandhumans.org. The subject line of ALL emails should be the complete title of the application. Multiple attachments or emails *will* be accepted. Additionally, submit a paper version of the completed application (one complete set of all required paper work, with original signatures) to:

USPS (regular U.S. mail):
Horses & Humans Research Foundation
P.O. Box 23367
Chagrin Falls, OH 44022 USA

UPS/FEDEX:
Horses & Humans Research Foundation
15670 Chardon Windsor Rd
Huntsburg, OH 44046 USA

Horses and Humans Research Foundation (HHRF) must receive the completed application by the end of the business day on the established deadline (Should the deadline fall on a weekend or holiday, the due date is the closest **preceding** business day). The main contact listed on the application will be sent a notice (by email or mail) of receipt of their application within two weeks of the HHRF office receiving it. If the applicant does not receive such a confirmation, inquire at info@horsesandhumans.org.

HHRF Research Grant Application Cover Page

Title of Project: Tracking Kinematic and Kinetic Data during Horse Riding for Optimizing Therapeutic Outcomes   Submission Date: 7/14/2017

Principal Investigator Name and Title: Pilwon Hur, Ph.D., Assistant Professor

Contact Name and Title: Pilwon Hur, Ph.D., Assistant Professor

(NOTE: The contact person is the only person with whom HHRF will have direct contact. The contact person receives all letters and notification from the HHRF office.)

Institute: Texas A&M University

Address (provide physical AND mailing addresses, if different): 3123 TAMU, College Station, TX 77843-3123

Telephone Number: 979-862-4461   FAX Number: 979-845-3081

Email Address: pilwonhur@tamu.edu   URL: http://hurgroup.net

Primary focus area of the investigation (i.e. mental health, physical therapy, speech therapy, occupational therapy, education, recreation, the horse-human relationship): physical therapy

Years and Titles of past HHRF Funding Applications: N/A

Safety and quality standards for EAA/T:

Name(s) of personnel directly involved with any associated EAA/T:

Nancy Krenek, PT, DPT, HPCS, PATH Intl Instructor (#12564)

Priscilla Lightsey, PT, DPT, HPCS, PATH Intl Instructor (# 29146)

Are all listed personnel certified to provide the activities? Yes

Certifying organization's name, website and contact information, or evidence of equivalent standards adhered to (please attach explanation if necessary): PATH Intl, www.pathintl.org, Phone: 1800369 RIDE (7433)

Site standards for EAA/T:

Is the site providing EAA/T programming accredited to do so? Yes   Member Number: #.40603

Accrediting organization's name, website address and contact information, or evidence of equivalent standards adhered to (please attach explanation if necessary): PATH Intl, www.pathintl.org, Phone 1800368 RIDE (7433)

Will others collaborate or consult with you on this project?   No

If yes, list Individuals or Organizations collaborating on project:

Attach letters to you that state collaborating individuals or organizations agreement to do so.

Brief description of project (60 words or less):

Pilot Study Completed?   Yes   Completion Date: 12/31/2016

Planned start date of project: 1/1/2018

End date of project: 12/31/2018

Amount Requested from HHRF: $10,000

II. Scientific Abstract

The research will use novel, and technologically-advanced sensors (portable, low-cost, real-time) to track movements of the horse and rider, enabling equine assisted therapy (EAT) professionals to observe and track progress towards therapeutic objectives at levels of detail, not previously possible. Research has shown the effectiveness of EAT, through translation of movement to the rider, in improving balance, gait, and social activities for a number of pathological conditions (e.g., cerebral palsy, multiple sclerosis, autism). Capturing kinematic and kinetic data for both the client and horse can yield valuable information to enhance therapeutic treatments and outcomes. The data collected by the sensors from the client and horse during EAT sessions will provide insight into: i) the impact of the equine movement on the rider during an EAT session, ii) the effects of the movement pattern of specific horses paired with specific riders on the rider's mobility, iii) how EAT affects the rider's core movements, and iv) how refinements in horse selection, utilization and/or training might further enhance effectiveness of an EAT session (horse-rider coordination). In addition, sensor data will enable EAT professionals to more accurately determine movements of the horse that are beneficial to improve rider's functional gait and balance.

III. Need/Justification

In EAT, including hippotherapy (HPOT), the translation of movement from the horse to the client is key to therapeutic benefits. However, understanding of kinematic/kinetic details is lacking, which may limit efforts by therapists to objectively evaluate, set goals, and monitor participant progress. Kinematic and kinetic measurements of physical activity can provide evidence of EAT having significant positive impact on balance and strength (Bronson et al., 2010; Giagazoglou et al., 2012). With some success, video cameras, motion capture technology, and 3-dimensional accelerometers have been used to quantify or categorize body motion of the riders (Garner and Rigby, 2015; Munz et al., 2014; Seo et al., 2017). However, methods from such studies are not scalable to individual functional motor outcomes and therapeutic decision-making. With few standardized measures, the EAT industry lacks the means to ascertain how outcomes are affected by variation between patients, disease conditions, horses, therapy sessions, phases of progress, or elements of the therapeutic plan. It is also challenging to make valid comparisons within individuals or to able-bodied riders.

This study addresses clinical needs of EAT with advancements in sensor technology and affordability. Methods proposed here have captured and rendered kinematic/kinetic data from sensors placed directly on the horse and rider, measuring and visualizing changes in orientation of the attachment surface, position in 3D space, latency between horse-rider movement, and proxy measures for stiffness and dampening coefficients with outcomes that suggest interpretation as stiffness, balance and strength.

The specialized, miniaturized sensors will quantify kinematic and kinetic interactions over time. The sensors will provide unprecedented, recordable, and objective information to the therapist during a hippotherapy session, as well as longitudinally across sessions. Thus, therapists will be able to visualize and track movements – horse, human, and combined human-horse interactions - noting changes over time.

IV. Research Narrative

1. Research question

First, please note that the proposed method applies to both EAA and EAT. However, this project will focus on EAT, specifically HPOT. EAT has been known for its efficiency in enhancing balance (Hamill et al., 2007; Silkwood-Sherer and Warmbier, 2007), gait (Beinotti et al., 2010; McGibbon et al., 1998) and social activities (Miller and Alston, 2004) for the people with pathological conditions (e.g., stroke, Parkinson's disease, spinal cord injuries, multiple sclerosis, autism, cerebral palsy). Researchers have found that several features (e.g., increased muscle strength

(Asselin et al., 2012), stabilized head/trunk movements (Champagne, 2010), enhanced postural sway (Shurtleff and Engsberg, 2012)) have contributed to the enhancement of the motor outcomes of those populations. However, most of the studies could provide qualitative and observation-based exposition and interpretation of the motor enhancement. Methods from these studies are not scalable to individual functional motor outcomes and therapeutic decision support. With few standardized measures, the EAT industry lacks the means to ascertain how results are affected by variation between patients, disease conditions, horses, variation in tempo, velocity, or degree of straightness of horse's movement pattern, or other elements of the therapeutic plan. It is also challenging to make valid comparisons within individuals or to able-bodied rider development.

Using the sensors to track quantitative measures over multiple HPOT sessions, the data can demonstrate changes of motor enhancement. These findings may include changes in trunk range of motion or control, in-phase or out-of-phase coordination between the client and the horse, leading or lagging of movement patterns of the client and the horse, interactive stiffness between the client and the horse. Therefore, it is worth investigating how the time evolution of kinematic/kinetic data during HPOT sessions is correlated with gains in functional motor skills.

Research question: Are the functional motor changes obtained following HPOT sessions reflected in the kinematic/kinetic data throughout the progression of therapeutic sessions? In other words, is there any correlation between the functional motor enhancement and the evolution of kinematic/kinetic data throughout the EAT sessions?

2. Specific Aim, Hypothesis and Significance

To answer the research question, the following specific aim and hypothesis will be investigated. *Aim: Determine if the enhancement of motor functions is correlated with several kinematic/kinetic sensor data throughout the HPOT sessions.* The proposed kinematic/kinetic sensor data (see

Method Section) will represent movement patterns, core strength, and coordination between the rider and the horse. *It is hypothesized that* as the motor functions of the client is enhanced due to HPOT, the time evolution of features from movement patterns, core strength, and coordination between the rider and the horse can reflect the enhancement. Specifically, the extent of the enhancement of motor functions will be correlated with the extent of changes in (and the quality of) the features from movement patterns, core strength, and coordination between the rider and the horse. *This hypothesis is established based on* several reports from the literature suggesting that gross motor function measures are associated with the improvement of postural control of the upper body (e.g., head, trunk). Postural control and alignment heavily influence functional motor skills such as sitting or walking. Postural control is affected by alignment of the head and trunk as well as various movement strategies to maintain stability. The sensors in this study will be able to track postural control including jerkiness, amplitude, and frequency of sway movements.

The *expected outcomes* of the proposed research are i) the objective findings of the enhancement of the gross motor functions are quantitatively correlated with the improvement of kinematic/kinetic sensor data, and ii) the wireless and portable sensors, user interfaces and evaluation tools can be easily utilized in the EAT industry, including HPOT. These outcomes *will have important positive impacts* since the information collected from the sensors will reflect whether or not the desired outcomes have been achieved. The therapist can modify the treatment strategy by reviewing the data to determine which aspects of the session were most beneficial, and which were not.

This ability for the therapist to modify a treatment as a result the sensor data has *profound significance to the EAT industry* as it has the potential to lower the number of treatments and the overall cost for the client. Further, *insurance companies* would likely view this as positive because the data collected from the sensors would enable therapists to determine if the current treatment was providing the results intended or not.

3. Design

1st generation sensors: To test the framework of wireless and portable sensors, user interfaces and evaluation tools, our research team had developed wearable sensors and the required wireless networks (Figure 1). The sensor comprises an Inertial Measurement Unit (IMU), microprocessor, the wireless communication unit (both transducer and receiver). Figure 1 shows the first design of the sensors. It can sample the 3-dimensional acceleration, 3-dimensional rotation (i.e., gyroscope), and 3-dimensional geo-orientation (i.e., magnetometer) with up to 200 Hz. One set of 6 identical sensors is connected wirelessly via a wireless communication protocol (XBee and Bluetooth).

2nd generation sensors: Even though the 1st generation sensors worked as we wanted, the team considered them too large as they may have distracted the participants during the session. A smaller size was selected without sacrificing the performance. Figure 2 shows the 2nd generation sensors with the smaller size (about the size of a quarter) with the same performance. Due to the small size of the sensor, the data could not be sent over a wide range for real time communication between the sensor and the data station. To resolve this issue, we added one data hub that can enable the real-time communication. The size of the data hub is about 85 mm by 55 mm by 15 mm (about the size of credit card), which can be placed at the girth of the saddle to avoid distracting the client.

Subjects: The framework proposed in this project can be applied to various populations. However, to minimize the unwanted effect of biases, we will control the subject population to children with cerebral palsy. *Inclusion criteria* will include i) a diagnosis of bilateral spastic CP attributed to complications of prematurity, intracranial hemorrhage, and periventricular leukomalacia according to the definition of Bax; ii) aged 3 to 14 years; iii) no treatment of botulinum toxin, orthopedic surgery and neurosurgery within the 6 months before the onset of training; iv) Gross Motor

Function Classification System (GMFCS) level I and II; v) able to signal pain, fear, or discomfort reliably; vi) with mild scoliosis (Cobb angle < 20°); vii) passive range of motion within functional limits; and viii) able to follow instructions.

Recruitment Plan: Four subjects who have not participated in HPOT within the last 12 months will be recruited either from TAMUS Courtney Cares in College Station, TX or R.O.C.K. in Georgetown, TX. Clients who are eligible for research participation according to the inclusion criteria will be asked under the guidance of their legal guardian if they are interested in the participation. All consent procedures will be approved by the Institutional Review Board. TAMUS Courtney Cares and R.O.C.K are the EAT facilities for this proposed project, where the average enrollment of children with cerebral palsy is 5 and 20, respectively. Both programs are Premier Accredited PATH International Centers.

4. Methods (including Pilot Testing and IRB process)

Experimental protocol: Subjects will participate in their normal HPOT sessions. Data will be collected and logged on the 1st, 4th, and 8th sessions. The 1st session data will serve as the baseline data. The 8th session data will serve as the post-evaluation. The 4th session data will serve as the mid-evaluation. The interval between each session is typically a week.

On the first visit, before the EAT session starts, the subject's functional motor performance (see 5. Measures for details) will be measured. After the measurement, three sensors will be attached to the client at i) the top of the head, ii) the back (T8, about the same height as the xiphoid process of the sternum), and iii) the pelvis (around the sacrum) (Figure 3a). The other three sensors will be attached to the horse at i) the top of the head, ii) the end of the saddle, and iii) the girth (Figure 3b). Since the sensors are about the size of a quarter, they are not expected to distract either the subject or the horse. Then, the normal session will be performed and videotaped to log any specific events. Note that the client's strengths, weaknesses, and abilities vary greatly making it impractical to have a set protocol for the sessions. Therefore, each HPOT session will follow the plan of care outlined for that particular client.

On the 4th and 8th visits, sensors will be attached to the subject and the horse in the same locations as in the 1st visit. The subject will undergo the HPOT session. As in the 1st visit, the riding will be videotaped. After the riding is completed, subject's functional motor performance (see 5. Measures for details) will be measured.

Pilot testing with preliminary data: During summer 2016, we conducted a few pilot testing with physical therapists using the 1st generation sensors. Six sensors were attached to the same location as detailed above. We collected and processed the sensor data to get information about movement patterns, coordination, core strength, and interaction between the rider and horse (Figure 4-7). The plots show that the processed sensor data could identify events, the interaction between the rider and the horse, and coordination between the rider and the horse.

5. Measures

Functional measures: The measures will be the Modified Timed Up and Go, a reliable measure for children with CP (Dhote, Kharti, & Ganvir; 2012), and postural sway using a force plate (OR6, AMTI, Watertown, MA, USA).

Sensor data processing: The raw data from each sensor will include 3-dimensional acceleration, 3-dimensional rotational speed, and 3-dimensional magnetic orientation (Figure 4). Mean, root-mean-square (RMS), and peak values of the raw data will be computed to provide descriptive information of the movement. Time-frequency plot will be computed using short-time Fourier transform of the raw data, which will provide information about movement patterns (Figure 6b). Cross correlation, i.e., correlation coefficient and phase shift (Figure 6a) and Granger correlation will be computed to obtain information about coordination and causal relation of horse-rider interactions, respectively (Kleinberg and Hripcsak, 2011). Finally, a horse-client interaction model will be introduced using a mass-spring-damper model to understand how the two dynamic systems are interacting with each other (Figure 7). The spring and damper concepts provide the coupling intensity between the rider and horse. This coupling is known to flexibly change depending on the client's tasks (Munz et al., 2014). Please note that the detailed mathematical description of the model is omitted by our own discretion.

6. Analysis

T determine if the changes in functional motor outcomes are correlated with the time evolution of wearable sensor data (See 5. Measure), Pearson's correlation analysis and regression analysis will be conducted. If the trend between two data sets is nonlinear, then we will use a non-parametric Mann-Kendall test. Significance level will be set to α=0.05 (SPSS, v21, Chicago, IL, USA).

V. Proposed Time Line

Time Table				
	Q1 2018	Q2 2018	Q3 2018	Q4 2018
Recruitment	X	X		
Data Collection	X	X	X	
Data Analysis		X	X	
Mid Report Preparation		X		
Abstract and Manuscript Preparation			X	X
Grant Proposal Preparation (NIH R21)				X
Final Report Preparation				X

VI. Intent to Publish

The findings from this project will be presented to academic society as well as EAA/T industry communities. Especially, we are targeting to present findings to PATH International or American Hippotherapy Association Conference. Additionally, we will prepare two manuscripts (one on journals about devices and hardware development, and one on the clinical journal). Finally, we will apply for bigger grants (e.g., NIH R21 or R01 NICHD for Human-Animal Interaction (HAI) Research) to extend the proposed framework and conduct experiments on multiple pathological populations with randomized controlled trials.

VII. Budget

All budget items must be related directly to the research question and methodology and will be prorated. Larger grants may be paid in progressive payments, checks written only after progress reports are sufficiently completed. All budget referrals should be related in U.S. dollars. **Please provide itemized budget <u>and</u> narrative justification. No indirect costs are allowed.** There are no word limits to this section, however, please be concise in explanation.

TOTAL GRANT REQUEST (US Funds): $

1) **PERSONNEL:** *(Principal investigator, co-investigator, statistician, research assistant)* Please describe scope of work, salary, fringe benefits, FTE.

One graduate research assistant for one semester is requested.

Salary: $1,700 (per month) × 4.5 (mo) = $7,650

Fringe benefit: $158

Insurance: $1,158

Total: $8,966

Personnel Total: $8,966

Personnel % of total budget:90%

2) **PERMANENT EQUIPMENT:** Itemize and describe purpose, justification of needs, how it will be acquired, etc.

Permanent Equipment Total: $0

Permanent Equipment % of total budget:0

3) **CONSUMABLE SUPPLIES:** Itemize and describe justification of needs, how it will be acquired, etc.

Sensors (IMUs + Microprocessors + Communication Units): $750

Batteries: $100

3D printing: $100

Office Supplies: $84

Consumable Supplies Total: $1,034

Consumable Supplies % of total budget:10%

4) **CONSULTANT COSTS**: Describe rate of pay, scope of work, justification of need, etc.

Consultant Costs Total: $0

Consultant Costs % of total budget:0%

5) **TRAVEL**: *(Will only cover subject travel reimbursement or for meeting of work groups.*)

Travel Costs Total: $0

Travel % of total Budget:0%

6) **CLIENT-RELATED EXPENSES**: Itemize and describe all related costs.

Client-Related Expenses Total: $0

Client-Related Expenses % of total budget:0%

7) **HORSE EXPENSE:** *(Must be directly related to research question and methodology.)* Explain cost basis related to percentage of time used in project.

Horse Expense Total: $0

Horse Expenses % of total budget:0%

8) **BUDGET JUSTIFICATION:** Please provide any further budget justification or explanation here.

OTHER INCOME SOURCES and ANTICIPATED FUNDING SUPPORT:

a. Active/Committed: Is this project being funded by other sources (federal, institutional and/or private grants or other sources)? Please provide source/institution name, project titles, specified designations and restrictions, starting and ending dates and amounts. Do not include general or overall program support.

The proposed study has not been funded yet. The PI used his own research funding for the Pilot study and prototyping. It is the PI's intention that the PI will apply for the bigger extramural funding based on the findings funded by this HHRF.

Total Active/Committed: $0

b. Pending: Is support for this project being sought elsewhere? Please provide source/institution name, project titles, specified designations and restrictions, starting and ending dates and amounts.

Total Pending: $0

c. Related Support: List all other sources of support, pending or current, including federal (NIH, VA, NSF, etc.), foundation, industrial, or other. Give complete titles of all grants as well as total funding, yearly funding, funding for your salary, funding for your research, and inclusive funding dates.

Active:

1. Pilwon Hur (PI), Reza Langari (Co-PI), Byung-Jun Yoon (Co-PI) “Robotic rehabilitation framework for the upper limb deficiency patient via myoelectric control interface with skin stretch feedback,” PESCA, Division of Research, TAMU, ($25,000, Prorated: $25,000) May. 2017 - Apr. 2018

2. Pilwon Hur (PI), “Enhancing balance of the aged workers via sensory augmentation toward the reduction of injuries due to falls,” NIOSH, Pilot Project Research Training, 5T42OH008421, ($10,000, Prorated: $10,000) Aug. 2016 - Jul. 2017

3. Pilwon Hur (PI), Texas A&M University ($440,000, Prorated: $440,000) Sep. 2014 - Aug. 2017

Pending:

1. Pilwon Hur (PI), Duane Steward, Nancy Krenek, Priscilla Lightsey, “Tracking kinematic and kinetic data during horse riding for optimizing therapeutic outcomes,” HHRF, ($10,000, Prorated: $10,000)

2. Pilwon Hur (PI) “Linking Biomechanics to Functional Outcomes for the Transfemoral Amputees Wearing Powered Prosthesis,” AOPA, ($15,000, Prorated: $15,000)

3. Pilwon Hur (PI) “CAREER: Unified Frameworks for Robotic Bipedal Walking with Perturbations,” NSF ENG/CMMI/DCSD, ($500,000, Prorated: $500,000)

4. Manoranjan Majji (PI), Robert Skelton, Raktim Bhattacharya, and Pilwon Hur “Structure Control Co-Design for Rehabilitative and Prosthetic Systems,” NSF CPS, ($671,738, Prorated: $242,928)

5. Pilwon Hur (PI) “Sensory Augmentation via Skin Stretch Feedback to Enhance Standing Balance of the Elderly,” NIH NIA, ($385,883, Prorated: $385,883)

6. Pilwon Hur (PI) “Muscle Synergy as a Targeted Motor Rehabilitation Tool for Slip Recovery,” NIH NICHD, ($373,854, Prorated: $373,854)

g9. Pilwon Hur (PI), Lynntech (Company), “Wearable Haptic Feedback Rehabilitation Tool,” NIH NIA SBIR, ($150,000, Prorated: $69,053)

Total Related Support: $475,000 (Active), $1,596,718 (Pending)

VIII. Lay Language Article

Date: 7/14/2017
Title of Project: Tracking Kinematic and Kinetic Data during Horse Riding for Optimizing Therapeutic Outcomes
Name of Principal Investigator: Pilwon Hur, Ph.D.

Approximately 400 words in lay language, understandable to 12th grade education level and suitable for use in HHRF and related publications as determined by HHRF. This should include information on the research question, the innovation aspect of your project, the need for the research, and general explanation of the methodology, procedures, analysis and any other applicable information.

This study will investigate the impact the movement of a horse has on the rider by measuring both horse and rider simultaneously. This innovative project relies on new, technologically advanced sensors (n=6), to be placed on both rider (n=3) and horse (n=3), to collect data on the movements experienced by the rider while on the dynamic surface of the horse.

The movement of the horse is a key factor contributing to the success of equine assisted therapies (EAT) as demonstrated by previous studies using both qualitative and quantitative data. As the EAT industry grows and expands, a tool that measures the horse movement and rider movement is necessary. The tool can quantify the biofeedback responses that the rider receives from the rhythmical, symmetrical movement of the horse. For instructors and therapist, this information could be groundbreaking in assessment of individuals, therapy horses, and treatment strategies.

Methodology includes the measurement sensors placed on both horse and rider. These tiny wearable sensors will measure various aspects of the horse and the rider's movements. Data will be collected in real-time as well as stored in a computer database. Advanced mathematical tools will provide intuitive information about coordination and interaction between the rider and the horse. A riding instructor can determine which movements were beneficial, and which were not, for the rider using this data.

IRB approval will be obtained through Texas A&M University (TAMU) to enroll four subjects for 8 weeks. The participants and the horse will have the sensors attached to them in locations such as head, back, and chest of subjects, to obtain data about the movement. To evaluate the findings, correlation between motor functions and sensor data outcomes including coordination and interaction between the rider and horse will be analyzed.

IX. Biographical Sketch of Principal Investigator - Professional information on the principal investigator, co-investigator(s), statistician and/or research assistant. Principal investigators must have a reputation for completing projects, publishing results in an expeditious manner and cooperating with funding agencies in providing reports and educational materials.

Include the following:

- Education (Begin with baccalaureate or other initial professional education, such as nursing, and include postdoctoral training. Information should include institution name and location, name of degree and year conferred, and field of study.)
- Research and professional experience (Previous employment and honors)
- Titles, authors, dates and complete references for a sampling of major publications during the past 3 years and earlier publications pertinent to this application.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Pilwon Hur

eRA COMMONS USER NAME (credential, e.g., agency login): pilwonhur

POSITION TITLE: Assistant Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Hanyang University, Seoul, Korea	BS	08/2004	Mechanical Engineering
Korea Advanced Institute of Science and Technology, Daejeon, Korea	MS	08/2006	Mechanical Engineering
University of Illinois at Urbana-Champaign	MS	05/2010	Applied Mathematics
University of Illinois at Urbana-Champaign	PhD	12/2010	Mechanical Engineering Biomechanics
University of Wisconsin-Milwaukee	Postdoc	06/2014	Rehabilitation, Biomechanics, Neuromechanics

NOTE: The Biographical Sketch may not exceed five pages. Follow the formats and instructions below.

A. Personal Statement

My long term research goal is to help people gain increased physical capability of the lower limb to perform activities of daily living by means of rehabilitation robots. To accomplish these goals, I have been conducting research on neuro/biomechanics and rehabilitation of lower limbs disabilities and weakness. As I started my new career as a tenure-track assistant professor at Texas A&M University in 2014, I am qualified to perform the proposed research since I have solid backgrounds/experiences on research in neuro/biomechanics, rehabilitation, control theory and mathematics as evidenced by peer-reviewed journal papers and conference proceedings. I have 24 published/forthcoming journal articles and 54 conference proceedings/abstracts and 32 invited talks in the fields of biomechanics, neuromechanics, rehabilitation, robotics, human factors, ergonomics, control, and virtual reality for the populations of the elderly, stroke patients, occupational workers, etc. I have successfully collaborated with several physicians and physical/occupational therapists and consultants across disciplines. So far, I have graduated 4 Master's students, have been mentoring 9 graduate students and 1 postdoc researcher for their independent research in Human Rehabilitation (HUR) Group at Texas A&M University since 2014.

Training: I received my Ph.D. degree in 2010 from the Department of Mechanical Science and Engineering at the University of Illinois at Urbana-Champaign in the area of biomechanics and postural control under supervision of Dr. Elizabeth Hsiao-Wecksler. I have conducted several research on the gait and balance of elderly adults and firefighters. I had 4 year postdoctoral research experience at the Center for Ergonomics in the Department of Industrial Engineering at the University of Wisconsin-Milwaukee, conducting research in rehabilitation engineering and hand neuromuscular control post stroke, gait analysis and ergonomics for upper limb. During this periods, I had several opportunities for grant writing. Among the funded research as a PI, AHA postdoctoral fellowship award was one of a meaningful accomplishment. I initiated research using stochastic resonance via subthreshold vibrotactile stimulation for sensory rehabilitation of stroke patients. I received my master's degree in 2006 from the Department of Mechanical Engineering at Korea Advanced Institute of Science and Technology (KAIST) in the area of Virtual Reality. I also received another master's degree in 2010 from the Department of Mathematics at the University of Illinois in the area of Optimization and Analysis. I received my bachelor's degree in 2004 from the Department of Mechanical Engineering at the Hanyang University. My specific interests during my undergraduate school were robotics, mechatronics, and automatic control.

Technical expertise: At Texas A&M University, we are conducting research on building rehabilitation robots and neuro/biomechanical studies of human walking. Specifically, my research group has developed a skin stretch device to help people with balance problems enhance better balance. We are now expanding the research on sensory augmentation to better understand balance enhancement mechanisms. We have also developed a powered transfemoral prosthesis for the amputee patients. We are currently conducting experiments on biomechanical and physiological analysis with the amputee patients wearing our prosthetics. For this purpose, we also collaborate local prosthetics company and local rehabilitation center. We are developing upper limb rehabilitation device for stroke patients using gyroscopic effect. We have designed balance rehabilitation device which will be used for the proposed research. We do neuro/biomechanical studies on human walking and slipping. All of the related control algorithms, neuromechanical resarch, and electronic circuits have been developed in my research group.

Based on my qualification, I am confident to accomplish those Aims in this application. Specifically, I can successfully accomplish research design, experimental setup, subject recruitment, student advising, and manuscript writing.

Four peer reviewed publications relevant to this project.

1. Mohammad Moein Nazifi, Han Ul Yoon, Kurt Beschorner, and Pilwon Hur, (2017) "Shared and Task-Specific Muscle Synergies During Normal Walking and Slipping", Frontiers in Human Neuroscience, Vol 11:40
2. Yitsen Pan, Han Yoon, and Pilwon Hur, (2017) "A Portable Sensory Augmentation Device for Balance Rehabilitation Using Fingertip Skin Stretch Feedback", Neural System and Rehabilitation Engineering, IEEE Transactions on, Vol 25, Issue 1, pp28-36
3. Victor Paredes, Woolim Hong, Shawanee Patrick, Huihua Zhao, Aaron Ames and Pilwon Hur, "Upslope Walking with Transfemoral Prosthesis using Optimization based Spline Generation," IEEE/RSJ International Conference on Intelligent Robots and Systems, Daejeon, Korea, October 9-14, 2016
4. Na Jin Seo, Marcella Kosmopoulos, Leah R. Enders, and Pilwon Hur, (2014), "Effect of Remote Sensory Noise on Hand Function Post Stroke," Frontiers in Human Neuroscience, Vol 8:934
5. Pilwon Hur, Alex Shorter, Prashant Mehta, and Elizabeth Hsiao-Wecksler, (2012) "Invariant Density Analysis: modeling and analysis of the postural control system using Markov chains," IEEE Transactions on Biomedical Engineering, Vol 59, Issue 4, pp1094-1100

B. Positions and Honors

Positions and Employment

2001-2003	Software Engineer, Ministry of National Defense, Korea
2004-2006	Research Assistant, Korea Advanced Institute of Science and Technology, Daejeon, Korea
2006-2010	Instructor, Research and Teaching Assistant, University of Illinois, Urbana, IL
2010-2014	Postdoc Research Associate, University of Wisconsin-Milwaukee, WI
2014-	Assistant Professor, Mechanical Engineering, Texas A&M University, College Station, TX
2015-	Center for Remote Health Technologies and Systems, Texas A&M Experimentation Station

Awards or Honors

2004-2006	National Scholarship, Ministry of Science and Technology, Korea
2007	Schaller Award, Graduate Travel Award, University of Illinois
2009, 2010	Paul D. Doolen Scholarship on Aging, Alternate Winner, University of Illinois
2010	Travel Award, World Congress on Biomechanics
2012	American Heart Association Midwest Postdoctoral Fellowship

C. Contribution to Science

1. Balance and gait research: After I joined Texas A&M University, I initiated several research including rehabilitation via sensory augmentation, lower limb prosthetics, neuromuscular understanding of slipping and developing control algorithms of slip recovery via observation of human slipping. These re-

search are currently on-going. What is important is that understanding how human recover from slipping can lead to better control of humanoid robots and lower limb prosthetics. Also, enhancing standing balance via sensory augmentation can lead to low-cost wearable in-home rehabilitation device to people with balance disorder.

Publications

i) Mohammad Moein Nazifi, Han Ul Yoon, Kurt Beschorner, and Pilwon Hur, (2017) "Shared and Task-Specific Muscle Synergies During Normal Walking and Slipping", Frontiers in Human Neuroscience, Vol 11:40

ii) Yitsen Pan, Han Yoon, and Pilwon Hur, (2017) "A Portable Sensory Augmentation Device for Balance Rehabilitation Using Fingertip Skin Stretch Feedback", Neural System and Rehabilitation Engineering, IEEE Transactions on, Vol 25, Issue 1, pp28-36

iii) Han Ul Yoon, Namita Anil Kumar, and Pilwon Hur, (2017) "Synergistic Effects on the Elderly People's Motor Control by Wearable Skin-Stretch Device Combined with Haptic Joystick," Frontiers in Neurorobotics, Vol 11:31

iv) Kenneth Chao, Matthew Powell, Aaron Ames, and Pilwon Hur, "Unification of Locomotion Pattern Generation and Control Lyapunov Function-Based Quadratic Programs," American Control Conference, Boston, June, pp3910-3915, 2016

v) Victor Paredes, Woolim Hong, Shawanee Patrick, Huihua Zhao, Aaron Ames and Pilwon Hur, "Upslope Walking with Transfemoral Prosthesis using Optimization based Spline Generation," IEEE/RSJ International Conference on Intelligent Robots and Systems, Daejeon, Korea, October 9-14, 2016

vi) Victor Paredes, and Pilwon Hur, "Push recovery by center of pressure manipulation," Dynamic Walking, Holly, MI, Jun 2016

vii) Kenneth Chao, and Pilwon Hur, "Toward general capture point-based analysis on standing, walk and slip: the connection between robotic motions to human behaviors," Dynamic Walking, Holly, MI, Jun 2016

2. Development of methodologies for quantifying human balance: I have worked on mathematical development of methodologies for quantifying human balance using control theory and stochastic modeling. Those methods could provide new insights that the previous methods could not provide on the standing balance. For example, the existing methods provided only descriptive postural sway information and could not provide information on robustness to unexpected perturbations which is more relevant to fall-incidences. Even though the existing statistical mechanics method (e.g., stabilogram diffusion analysis) could provide some insights about underlying control mechanisms for balance, it could not provide the detailed dynamics of the postural control system. I have developed two mathematical methods: 1) robustness measure and 2) invariant density analysis. Robustness measure could quantify how human can resist to unexpected perturbation, which provide more realistic and sensitive metric for balance. Invariant density analysis could explain the detailed stochastic behavior of balance, which could provide the direct information on the dynamics of postural control system. These methods have been applied to firefighters and elderly populations.

   Publications

   i) Pilwon Hur, Brett Duiser, Srinivasa Salapaka, and Elizabeth Hsiao-Wecksler, (2010) "Measuring robustness of the postural control system to a mild impulsive perturbation," IEEE Transactions on Neural Systems and Rehabilitation Engineering, Vol 18, Issue 4, pp 461-467

   ii) Pilwon Hur, Alex Shorter, Prashant Mehta, and Elizabeth Hsiao-Wecksler, (2012) "Invariant Density Analysis: modeling and analysis of the postural control system using Markov chains," IEEE Transactions on Biomedical Engineering, Vol 59, Issue 4, pp1094-1100

   iii) Pilwon Hur, Kiwon Park, Karl Rosengren, Gavin Horn and Elizabeth Hsiao-Wecksler, (2015), "Effects of air bottle design on postural control of firefighters," Applied Ergonomics, Vol 48, pp49-55

3. Development of a method that measure functional balance of firefighters: I investigated how design change of SCBA can enhance the balance of firefighters. However, measuring balance of firefighters right after strenuous drill was almost impossible since they could not stand quietly in place. Therefore, I came up with a novel method to measure functional balance of firefighters which firefighters could con-

duct even after the drill. This method measured scores from simple functional tasks including walking on a narrow plank, stepping up and down, stopping in an appropriate space, and ducking under an overhead obstacle.

Publications

i) Pilwon Hur, Karl Rosengren, Gavin Horn, Denise Smith, and Elizabeth Hsiao-Wecksler, (2013) "Effect of protective clothing and fatigue on functional balance of firefighters," J Ergonomics, S2: 004

ii) Kiwon Park, Pilwon Hur, Karl Rosengren, Gavin Horn, and Elizabeth Hsiao-Wecksler, (2010) "Effect of load carriage on gait due to firefighting air bottle configuration," Ergonomics, Vol 53, Issue 7, pp882-891

4. Biomechanical hand/finger models for preventing falls from the elevation in workplaces and biomechanical model for optimizing assistive gloves for stroke patients: I studied on preventing fall-related injuries from the elevation (e.g., ladders, and scaffold in the workplaces). One way of the fall prevention was via increasing breakaway strength by designing better rung. To do so, I developed a biomechanical model that can predict breakaway strength given the design of rung and coefficient of friction between hand-handle coupling. Later, when I needed to design different rung design, I had a serious problem. That is, to predict the breakaway strength from the model that I developed, I needed to input maximum power grip strength which was available only for the cylindrical handles. Therefore, I decided to design a biomechanically-correct index finger model that considered tendons, muscles, extensor mechanisms, pulley mechanisms due to sheaths, and mechanical properties of tendon and muscles. Via optimization process, I could successfully estimate the power grip strength for various shapes of handles. I have extended the hand/finger model to design the optimal assistive glove for stroke patients, which was later funded by a NIH R24 RIC Engineering.

   Publications

   i) Pilwon Hur, Binal Motawar, and Na Jin Seo, (2012) "Hand breakaway strength model – Effects of glove use and handle shapes on a person's hand strength to hold onto handles to prevent fall from elevation," Journal of Biomechanics, Vol 45, Issue 6, pp958-964

   ii) Pilwon Hur, Binal Motawar, and Na Jin Seo, (2014) "Muscular responses to handle perturbation with different glove condition," Journal of Electromyography & Kinesiology, Vol 24, Issue 1, pp159-164

5. Somatosensory enhancement via stochastic resonance post stroke: I examined stochastic resonance using subthreshold vibrotactile stimulation on stroke survivors to enhance their touch sensation. I developed testing protocol and all experimental environments and devices. Via the development of this research, I got AHA Midwest postdoctoral fellowship award and two students (one doctoral and one MS students) could graduate. The idea behind the stochastic resonance is that subshreshold noise is applied to the fingertip where the noise could somehow enhanced the touch sensation post stroke. Possible explanations could include the elevation of resting potential at the periphery or central nervous system. It turned out that periphery integration was not possible. Via EEG study, we figured out that the integration happened at the supuraspinal level.

   Publications

   i) Na Jin Seo, Marcella Kosmopoulos, Leah Enders, and Pilwon Hur (2014), "Effect of Remote Sensory Noise on Hand Function Post Stroke," Frontiers in Human Neuroscience, Vol 8, 934

   ii) Leah Enders, Pilwon Hur, Michelle Johnson, and Na Jin Seo (2013) "Remote vibrotactile noise improves light touch sensation in stroke survivors' fingertips via stochastic resonance," Journal of NeuroEng and Rehab, 10:105

   iii) Pilwon Hur, Ying-Ling Tseng, and Na Jin Seo, (2013) "Somatosensory cortex activity in response to fingertip stimulation can increase with remote subthreshold vibrotactile noise: An EEG study," American Society of Biomechanics, Sep, Omaha, NE, USA

   iv) Pilwon Hur, Yao-Hung Wan, and Na Jin Seo, (2014) "Investigating the role of vibrotactile noise in early response to perturbation," Biomedical Engineering, IEEE Transactions on, 61(6), pp1628-1633

D. Research Support

<u>Ongoing Research Support</u>

Agency: PESCA, Division of Research, TAMU (**Hur** PI) 05/17-04/18
Title: Robotic rehabilitation framework for the upper limb deficiency patient via myoelectric control interface with skin stretch feedback

Agency: NIOSH SWCOEH PPRT 5T42OH008421 (**Hur** PI) 08/16-07/17
Title: Enhancing balance of the aged workers via sensory augmentation toward the reduction of injuries due to falls

Agency: Texas A&M University (**Hur** PI) 09/14-08/17
Title: Startup Package for Assistant Professor

<u>Completed Research Support</u>

Agency: American Heart Association AHA 12090039 (**Hur** PI) 07/12-06/14
Title: Effect of enhancement of somatosensation on hand function post stroke
Role: PI

Agency: NIOSH UIC ERC T42 OH008672 (**Hur** PI) 07/11-06/12
Title: Prevention of Ladder Fall by Improved Somatosensation and Optimal Rung Design
Role: PI

Agency: NIOSH UIC ERC T42 OH008672 (**Seo** PI) 07/10-06/11
Title: Effects of glove and ladder rung design on fall from ladders
Role: Co-Investigator

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Nancy Krenek

eRA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Founder/CEO ROCK, Ride On Center for Kids; Director of TAMUS Courtney Cares,

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
West Texas A&M	BGS	05/81	General Studies
University of Texas Medical Branch	BS	09/84	Physical Therapy
University of Texas Medical Branch	DPT	09/14	Physical Therapy Doctorate

A. Personal Statement

I have the expertise, leadership, training, and motivation necessary to successfully carry out the proposed research project. I have a broad background in physical therapy, and equine assisted activities and therapy. I have been a leader in this industry for the past twenty years, in research, innovative treatment and higher learning. In addition, I successfully administered the equine and client portion of several research projects, two of which have been published and one that has been submitted to a peer review journal. As a result of these previous experiences, I am aware of how critical good communication and a good team is for research.

B. Positions and Honors

Work Experience

1984-1986 Shriner's Burn Hospital, Staff Physical Therapist
1986-1991 Northwest Hospital, Tucson, Arizona, Staff Physical Therapist
1991-1993 Sedalia Public School district, Pediatric Physical Therapist
1993-1994 Cypresswood Physical Therapy, Houston, Texas
1995-1998 Georgetown Independent School District, Georgetown, Texas, Staff Therapist
1995-2001 Georgetown Physical Therapy, Georgetown, Texas
1998-present ROCK, Ride On Center for Kids, Founder, CEO, Physical Therapist, Georgetown, Texas
2012-present TAMUS Courtney Grimshaw Fowler Equine Therapeutic Program, Director, College Station, Texas

Other Experience and Professional Memberships

1984-present Member, American Physical Therapy Association
1991-present Member, North American Riding for the Handicap Association
2001-present American Hippotherapy Association
2011-present Member, Professional Association of Therapeutic Horsemanship International

Honors

2006 Champions for Children, Austin, Texas
2008 Citizen of the Year, Georgetown Chamber of Commerce
2009 Paul Harris Fellow Award Rotary International
2010 Service to Mankind Award, Georgetown Sertoma

C. Contribution to Science

1. In 2005 I began working with veterans who had sustained physical and mental injuries from serving in the military. This work led to writings, training videos and ultimately research which have increased awareness of EAAT as a healing source for veterans to this day.

   Published References:

   Lanning, B., Krenek, N., (2013) Examining effects of equine-assisted activities to help combat veterans improve qualify of life. *Journal of Rehabilitation and Research*, 50(8), 7-13.

2. In addition to the work described above, with a team of collaborators, I have participated and worked with children with autism and EAAT which has led to several studies.

   Published References:

   Lanning, B., Baier, M., Ivey-Hatz, J., Krenek, N., Tubbs, J., (2014) Effects of Equine Assisted Activities on Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders* 44 (8), 1897-1907

3. Continued work with Dr. Beth Lanning which was funded by HHRF.

   Published References: LanningB., Wilson,A., Krenek,N., (2017). Using Therapeutic Riding as an Intervention for Combat Veterans: An International Classification of Functioning Disability, and Health (ICF) Approach. *Occupational Therapy in Mental Health.* Retrieved from http://dx.doi.org/10.1080/0164212X2017.1283282

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Priscilla Lightsey

ERA COMMONS USER NAME (credential, e.g., agency login):

POSITION TITLE: Physical Therapist, ROCK (Ride on Center for Kids)

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Texas A&M University	BS	12/80	BS in Education, endorsement in Special Education
University of New Mexico	MA	05/90	MA in Special Ed, emphasis on Early Childhood
Texas State University	MSPT	05/99	Master of Science in Physical Therapy
University of Texas Medical Branch, Galveston	DPT	05/14	Doctorate in Physical Therapy

A. Personal Statement

My personal goal is to enhance the lives of individuals with challenges by partnering with the horse. I have the experience, expertise, and stro desire to effectively complete the research project. My background includes extensive knowledge in equine assisted activities and therapy (EA as well as in the field of Physical Therapy (PT). As leader in the EAAT field, I founded HOPE (Horses Offering People Enrichment) Therapy Services Beijing, China in 2009 when taking a sabbatical from serving as PT at ROCK (Ride on Center for Kids) in Texas. I feel that based on history, education, and passion for EAAT I am qualified to be a member of the research team for this study.

B. Positions and Honors

Work Experience

2009 – present	Founder/CEO HOPE Therapy Beijing	Beijing, PRC
1999-2006; 2013-present	PT at ROCK (Ride on Center for Kids)	Georgetown, TX
2013 – present	PT at TAMUS Courtney Grimshaw Fowler Equine Therapeutic Program	College Station, TX
2001-2005	PT at Georgetown Independent School District	Georgetown, TX
1999-2001	PT at Starbright/HealthSouth Pediatric Clinic	Austin, TX
1993-1996	Instructor at Kidsports, Inc.	Austin, TX
1991-1992	Service Coordinator at Alta Mira Specialized Family Services	Albq, NM
1986-1991	Team Leader/Special Ed teacher at Albuquerque Public Schools	Albq, NM
1985-1986	Therapeutic Riding Instructor at Cloud Dancers	Albq, NM
1983-1985	Early Childhood Coordinator at New Vistas	Santa Fe, NM
1980-1983	Early Childhood Teacher at Dallas Easter Seal Affiliate	Dallas, TX

Other Experience

2006	Worked with China Research and Rehabilitation Hospital to establish a hippotherapy (HPOT) program	Beijing, PRC
2009 & 2010	Lectured at Rehabilitation Hospital Conference on HPOT	Beijing, PRC
2007-2011	Riding for the Disabled (RDA) Taiwan, presented at annual conferences	Taipei, Taiwan
2010	Conducted HPOT 3-day course at Sung-Duk College	South Korea
2015	Conducted 1-day workshop on Therapeutic Horsemanship	Beijing, PRC
2017	Conducted 6-day workshop on Therapeutic Horsemanship	Beijing, PRC

Professional Memberships
American Physical Therapy Association (APTA), Pediatric Section
Texas Physical Therapy Association (TPTA)
PATH (Professional Association of Therapeutic Horsemanship) International
Horses in Education and Therapy International (HETI)
American Hippotherapy Association (AHA)

Certifications
Hippotherapy Clinical Specialist (HPCS)
PATH International Certified Riding Instructor

C. Contribution to Science

1. In 2005 conducted a case study on a child with agenesis of corpus callosum and low muscle tone. Published in the American Hippotherapy Association magazine.
2. In 2011 conducted a single case design on a child with spastic cerebral palsy for completion of DPT degree.
3. Data collected in spring of 2017 on a male subject with Multiple Sclerosis, with the prospect of reporting findings in a poster presentation.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Steward, Duane Allen

eRA COMMONS USER NAME (credential, e.g., agency login): DSTEWARD

POSITION TITLE: Research Assistant Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Florida State University	BS	6/1976	Biology
Univ of Florida, College of Veterinary Medciine	DVM	6/1980	Veterinary Medcine
Florida State University, College of Engineering	MSIE	12/1994	Industrial Engineering
Massachusetts Institute of Technology	PhD	9/1998	Computer Science
Harvard/MIT Fellshp Rsch Trng Med Informatics	Postdoctoral	9/1998	Knl Rep;Utility Assessm

A. Personal Statement

Duane Steward did his undergraduate work at Florida State University, earned his veterinary professional degree from University of Florida and entered private practice. The next 14 years were spent in clinical veterinary practice, 11 of which were as a sole proprietor of a small animal house-call practice. During the latter 5 years of this period, he simultaneously completed a master’s degree in Industrial Engineering at Florida State University/Florida Ag & Mech University College of Engineering. In 1994 his clinical practice was suspended in order to engage as a Fellow in the Harvard-MIT-New England Medical Center Research Training Program in Medical Informatics. A PhD in Computer Science was conferred in 1998 at MIT under the guidance of Peter Szolovits. Additional focus for this training came from participation informally as fellow in the Clinical Decision Making Division of New England Medical Center under Steve Pauker, et al. His research interest expressed at the master’s degree level centered on the application of process simulation tools to decision making in veterinary medical practice. Doctoral research was in the area of knowledge representation regarding the individual patient's perspective on what healthiness is, the means of assessing the patient's view of healthiness and the impact patient perspective inclusion in decision making has on compliance and health care outcomes. These credentials qualify Dr. Steward as a clinician, industrial engineer and computer scientist with research training in biomedical informatics well-suited to assist in systematic design and evaluation of data capture, repository development and quality measures in healthcare delivery.

From 2007 until January 2013, Dr Steward served as Chief Computer Scientist for Clinical Informatics at Nemours where responsibilities included clinical informatics research (e.g., practice guidelines implementation through information technology, impact of human-animal-bond/pet-ownership on pediatric care delivery and outcomes), model-based simulation (e.g., design of the Nemours Children's Hospital and process improvement) and feedback tool development (e.g., surgical morbidity and mortality data entry and national database contribution). During this time he also sat on the Health Information Exchange Coordinating Committee advising the Florida State Agency for Health Care Administration, the research committee of the Central Florida Regional Health Information Organization (RHIO) and the curriculum advisory committee for UCF's College of Medicine. As of July 1st, 2014, he was appointed Research Assistant Professor in the Center For Biomedical Informatics within the Texas A&M College of Medicine of the Health Science Center.

His perspectives on clinical implications of the human-animal bond are spawned from clinical veterinary practice development and a variety of corporate experiences. He has served as consultant to the Area Agency on Aging in Florida for the purpose of program development, volunteer training and animal screening with nursing home animal visitation. He is a thought leader in the veterinary medical profession and human pediatrics while positioned at Nemours. He has been privileged to collaborate with leaders in human animal bond research such as Aaron Katcher and Alan Beck and members of the One Health Initiative.

He has provided leadership in commercial IT divisions of Gartner and Scientific Applications International Corporation (SAIC). He has engineered software and architected distributed enterprise technology applications in various roles including CTO of a startup in Boston before returning to the health care industry in Florida. At the other end of the spectrum, he has managed a multi-national multi-million-dollar IT harmonization project for merging companies in the pharmaceutical industry. Dr. Steward has prevailed with model-based simulation to evaluate and validate numerous systems and solutions including: Orange County Health Department's Disaster Response Plan for Cities Readiness Project (CDC stockpiled medication distribution), Florida State Animal Disease Diagnostic Laboratory's planning for disease outbreak detection, and Nemours Children's Hospital pediatric emergency department operations. From these domains, he brings a familiarity with data domains that are characterized by lower sensitivity and specificity levels consistent with biomedical systems and inference from which accurate status determination is essential for decision support.

B. Positions and Honors

Positions and Employment

2014-	Assistnt Resch Prof, Ctr for Biomedical Informatics, Texas A&M Hlth Sci Ctr, Houston, TX
2015-2015	Visiting Associate Prof of Health Informatics, Florida Polytechnical Univ, Lakeland, FL
2013-2015	Consultant, acting Chf Sci Officer for Automated Clinical Guidelines, Palm Coast, Orlando. FL
2007-2012	Chf Cmptr Scientist For Health Informatics, Nemours, Orlando, FL
2006-2007	Research Associate, College of Health and Public Affairs, Univ of Central Florida, Orlando, FL
2003-2006	Principal Bioinformatics Engineer, Sci. Appl. Intl. Corp., Celebration, FL
2001-2003	Senior Director, Gartner, Inc., Maitland, FL
1999-2001	Director New Products, CTO, AssetStream Corporation, Woburn, MA (now Matthews, NC)
1999-1999	Senior Softw Engineer, Project Lead, WebCT (formerly Universal Learning Technology, Inc.)
1998-1999	Visiting Scientist, Clinical Decision Making Group, Laboratory for Computer Science, M.I.T.
1998-1999	Research Associate, Division of Nephrology, Department of Medicine, New Eng Med Center
1998-1999	Consulting Softw Developer, Laboratory of Computer Science, Massachusetts General Hospital
1994-1998	Fellow, National Institutes of Health Research Training in Medical Informatics
1983-1994	Sole proprietor of At Home Veterinary Services in Tallahassee, Florida
1981-1982	Clinician/Manager at Camelot Veterinary Hospital, Belleview, Florida
1980-1981	Clinician at Upper Keys Veterinary Hospital, Tavernier, Florida

Other Experience and Professional Memberships

2008-2012	Health Information Exchange Coordinating Committee; FL Agency for Health Care Adm
2006-2007	Member, UCF College of Medicine Curriculum Committee
2006-2007	Florida Health Information Network (FHIN) Budget Workgroup by request and appointment of the Governor's Health Information Infrastructure Advisory Board of the State of Florida
2006-2015	Board Member, Central/North FL Chapter, Health Information Management Systems Society
2006-2014	Clinical Committee Member; Central Florida Regional Healthcare Information Organization; Orlando, FL
2006-2014	Technical Committee Member; Central Florida Regional Healthcare Information Organization; Orlando, FL
2001-2013	Advisory Board Member, Veterinary Technologist Program, St. Petersburg College
1997-1998	Program Committee Chair for Talbot Symposium on Veterinary Informatics at the American Veterinary Medical Association Annual Convention, Baltimore, Md.
1993-	Society of Medical Decision Making (member)
1993-	American Academy of Veterinary Informatics (Charter Fellow by Appt, Advisory Board)
1992-	American Medical Informatics Association (member)
1983-2007	Veterinary Information Network (Consultant)
1988	Co-Chairman Fla. Vet. Med. Assoc. Committee on the Human-animal bond

Honors

1991 Charter Fellow of the American Academy for Veterinary Informatics, appointment by peers.

1992 Recognized for contributions to the Companions For Therapy (ComForT) program (Pet-facilitated therapy) by the District II Long-term Care Ombudsman Council

C. Contribution to Science

Reduction of average length of visit in pediatric emergency department of Nemours Children's Hospital with model-based simulation

To enable a novel approach to emergency department care, a model-based software simulation of workflow and throughput was developed to refine the design, communicate the vision and train staff prior to opening the Nemours Children's Hospital. Simulation was based on data and process variable value assumptions from analogous systems and subject matter expertise of the co-author, Chief of Pediatric Emergency Medicine. It embodied an extension of previous (co-author) research suggesting the Acute Care Model be manifest in the form of four variants representing patient stereotypic 'care streams'. The application of model-based simulation is asserted to have played a significant role in the successful adoption of the framework for care delivery, which for two years since has experienced an average length of visit that is 50% less with normal caseloads than elsewhere reported. Quantified validations of the modeling with the help of actual performance data is now underway, for which peer-reviewed publication waits.

[Publications unavailable]

Design of Pediatric Hospital Facilities

Nemours Children's Hospital, Orlando, FL, when constructed for opening in 2012, was the first free-standing pediatric hospital to be built from the ground up in over 25 years. Endowed for service to children of Delaware and Florida by Alfred I Dupont, the Nemours enterprise assumed a responsibility for establishing new precedents for pediatric facilities and care with this construction opportunity. In this circumstance, Dr. Steward was called upon to evaluate design proposals with model-based simulation and medical informatics as an industrial engineer. In addition to the aforementioned contribution to science, he was asked to evaluate facilities ability to accommodate the innovations of the project. Specific areas included entry, egress and security throughput; waiting area capacity for caseloads with projected unfamiliar cultural biases.

In addition, requirements analysis for infection control and the hospital's groundbreaking "tactical operations center" were projects that Dr. Steward contributed to in the process of facility and service development. Site specificity and propriety constrained publications regarding this effort.

Published References of Similar Work

1. Standridge, Charles R. and Steward, Duane. Using Expert Systems for Simulation Modeling of Patient Scheduling, Simulation, September, 2000.
2. Steward, Duane and Wan, Thomas T.H. Role of Simulation and Modeling In Disaster Management, Journal of Medical Systems, Journal of Medical Systems, March 21, 2007.
3. Steward, Duane; Hofler, Richard; Thaldorf, Carey; Milov, David E. A Method For Understanding Some Consequences Of Bringing Patient Generated Data Into Health Care Delivery, Journal of Medical Decision Making, July/August, 2010.

Utility Assessment Based on Individualized Patient Perspectives

A protocol was developed to capture what the patient values in health. The results of a structured interview are comprised of a multidimensional preference model that can be used to score health states in support of shared decision-making. The method of elicitation is a repackaging of components from repertory grid elicitation of bipolar constructs and legacy methods of utility assessment, including "standard gamble" and "time trade-off". The method innovated, programmed as software and documented as a doctoral degree dissertation by Dr. Steward.

Published References

1. Steward, Duane. Utility Assessment Based on Individualized Patient Perspectives, Proceedings of the Spring Symposium on Interactive and Mixed-Initiative Decision-Theoretic Systems, AAAI, March, 1998.
2. Steward, Duane. Utility Assessment Based on Individualized Patient Perspectives, Doctoral Thesis, Massachusetts Institute of Technology, September 1998.

3. Steward, Duane and Meyer, Klemens, MD. Feasibility of Systematically Using Patient Terminology in Utility Assessment, submitted to AMIA Fall Symposium, 1999.

Complete List of Published Work in SciENcv: http://www.ncbi.nlm.nih.gov/myncbi/10ENz0c085eQt/cv/20189/

D. Research Support

Ongoing Research Support

NIH ID: 1R44DA041757-01; SA1001 Drake (PI) 03/01/16-present
Service and Software Solution for the Rigorous Design of Animal Studies
The primary goal of this project is to commercialize a cloud-based software suite complemented with on-call expert services to guide life science researchers, that may have minimal statistical and experimental design (ED) knowledge, to rigorously plan, optimize, justify, manage, and report results for complex animal studies.

Role: Co-PI, liaison and facilitator to representative animal studies by PIs of the College of Medicine

Biomedical Informatics Dept funds Steward (PI) 03/01/16-present
Individualized Multidimensional Quality Of Life Model Elicitation Tool Recoding and Preliminary Clinical Trial
To better capture the values of patients in their own words, a previously developed protocol for eliciting preference models from patients will be recoded and experiments launched to evaluate results of use.

Role: PI

TAMU Sub to NIH Clin Trans Sci (U54) Steward (PI) 02/01/16-present
Determination Of The Competency Of Electronic Health Record Data To Support Outcomes Feedback For Medical Interventions
The overarching aim is to determine what the minimum data and metadata set is for effective integration of encounter outcomes as feedback for care plans and individualized adaptive medical care.

Role: PI

HRSA ID: D88HP28504 Voinea-Griffin (PI) 07/01/15-present
Patient first: a collaborative project to enhance postdoctoral training in public health and pediatric dentistry
The project objective is to enhance the postdoctoral of pediatric dentistry and dental public health training trough interprofessional education in community setting and didactic and experiential training in cultural competency, quality improvement, and practice transformation; Aims include utilization of quality measures and outcomes reporting in dentistry education.

Role: IT Development Program Director

Completed Research Support

Five years of employment as Chief Computer Scientist for Health Informatics at Nemours accounts for a period of time in which research and development was proprietary and peer review publication of limited value for the employer. Nonetheless, in contrast to typical circumstances where academic investigators are not immediately in possession of research data, the Nemours position represented a substantial legitimate access to data that enabled internal investigation, development and research in non-academic form. During his tenure, Dr. Steward participated as co-investigator on several research teams and proposals. Federally funded topics include Clinical Guideline digital implementation (2008-9) and Pediatric Obesity Management patient/coach/physician systems (2011), however, Dr. Steward was not directly funded by the grants.

- **HUMAN SUBJECTS**

COMPLIANCE WITH U.S. GOVERNMENT REQUIREMENTS

The following statements are signed by an individual authorized to act for the institution and to assume on behalf of the institution the obligations imposed by the following:

The _Pilwon Hur_ agrees that if a research grant is awarded by the Horses and Humans Research Foundation (HHRF) to _Pilwon Hur_ for the project _ Tracking Kinematic and Kinetic Data during Horse Riding for Optimizing Therapeutic Outcomes_ and if human subjects are used in any of the activities supported by such award, that it will comply with all applicable U.S. Department of Health and Human Services regulations with respect to the rights and welfare of such subjects. To the extent allowable by the State of _Texas_, the _Texas A&M University_ agrees to indemnify and hold HHRF harmless from any claims arising from such activities, and acknowledges that HHRF does not and will not assume responsibility for the subjects involved.

SIGNATURE OF APPROVAL BY THE DEAN OR HEAD OF INSTITUTION ON BEHALF OF INSTITUTION

Andreas A. Polycarpou

Signature

Andreas Polycarpou

Type/Print Name and Title of Dean or Head of Institution

_7/14/2017_

Date

ANIMAL SUBJECTS

COMPLIANCE WITH GOVERNMENT REQUIREMENTS

The following statements are signed by an individual authorized to act for the institution and to assume on behalf of the institution the obligations imposed by the following:

The _Pilwon Hur_ agrees that if a research grant is awarded by the Horses & Humans Research Foundation (HHF) to _Pilwon Hur_ for the project _Tracking Kinematic and Kinetic Data during Horse Riding for Optimizing Therapeutic Outcomes _ and if animal subjects are used in any of the activities supported by such award, that it will comply with all applicable U.S. Department of Health and Human Services regulations with respect to the rights and welfare of such subjects.

To the extent allowable by the State of _Texas_, the _Texas A&M University_ agrees to indemnify and hold HHRF harmless from any claims arising from such activities, and acknowledges that HHRF does not and will not assume responsibility for the subjects involved.

SIGNATURE OF APPROVAL BY THE DEAN OR HEAD OF INSTITUTION ON BEHALF OF INSTITUTION

Andreas A. Polycarpou

Signature

Andreas Polycarpou

Type/Print Name and Title of Dean or Head of Institution

_7/14/2017_

Date

XI. Research Grant Conditions of Award

1. At least one member of the research team must be fluent in English and published in peer-reviewed English language journals.
2. No institutional overhead or other indirect costs will be paid and should not be included as part of any grant request. A letter to your institution explaining this condition can be requested if needed. Beware that substantive equipment costs could work against the success of the grant request.
3. All funds awarded shall be used in accordance with the submitted and approved proposal and accompanying budget. Any unused portion thereof shall be returned to the Horses and Humans Research Foundation (HHRF). If an unforeseen problem occurs with the study design, notify HHRF immediately. Potential changes to the study design with additional financial assistance from HHRF may be considered to salvage the study and still lead to a favorable outcome.
4. Grant awards will be made in US dollars. Fifty percent will be awarded after the midpoint report is accepted and the remainder will be awarded when the project is fully completed, unless other arrangements have been specified and agreed to. The value of the grant will not be adjusted for inflation, cost over runs, or foreign exchange rate fluctuations. It is the responsibility of the recipient to manage these potential variables (example: if grant budget deals in euros, a loan could be purchased at the time of award, in US dollars, against the euro).
5. A one year grant period is assumed, unless otherwise specified in the application. At the midpoint of the grant period (6 Months) a progress report, financial report and invoice must be submitted for approval prior to receiving the first award check (up to 50%). A final report must be submitted within the agreed upon grant time line and must be approved before the final check is awarded. Projects that are incomplete within agreed time line may not receive final funding.
6. The Principal Investigator must assure HHRF of his or her intended work location. HHRF must be advised at the time of application of all moves, contemplated or real. Changes of address, phone number, fax number and email *within the same institution* must be promptly conveyed to HHRF. Changes in site location during a funded period must be approved by HHRF.
7. All publications (including poster abstracts at medical conferences) resulting from HHRF-funded research must include HHRF in a footnote/credit line/disclosure, and copies of such publications must be provided to HHRF. All publicity and information disseminated about such research must acknowledge HHRF support. This is an essential part of HHRF's conditions of award. Publicity or information about the project is used to keep supporters to HHRF informed about how their donations are being spent. This condition of award does NOT involve disclosure of any information that might jeopardize the applicant's ability to formally publish their findings.
8. The recipient of any research grant awarded must certify that any research, including work involving human and/or animal subjects, will be conducted according to the rules and regulations of the United States Department of Health and Human Services. The recipient must agree to hold HHRF harmless from any and all claims which may arise from any associations/issues related to such research.

9. All studies involving therapeutic riding horses must comply with accepted industry standards for care, treatment, and humane work load. All mounted work must comply with accepted industry standards for safety – including a certified instructor/therapist or evidence of equivalent standards. Therapeutic riding program sites must be accredited by or provide evidence of equivalent standards for facility safety.
10. A one year grant period is assumed. HHRF may approve the funding of a multi-year project, with funding of subsequent years pending the successful completion of the initial year. Applicants must consult HHRF prior to submitting a multi-year application.
11. Recipients of HHRF grants will be committed to a serious effort to publish resulting research findings in a peer-reviewed journal. HHRF will be kept informed of publication efforts.
12. All grant applicants must include one signed copy of this "Research Grant Conditions of Award" as a necessary part of their grant application to HHRF.
13. The Foundation reserves the right to terminate an award if the grant holder or staff funded by the grant is in breach of any of the conditions of award or becomes unfit or unable to pursue the work funded by the grant.

I have read and understood HHRF's "Research Grant Conditions of Award" and my signature below signifies that I agree to abide by all conditions specified.

Principal Investigator's signature: ________________________________ Date: _7/14/2017__

Principal Investigator's name and title (please print) _Pilwon Hur, Ph.D., Assistant Professor____

XII. Attachments

Copy of IRB Application

We are in the process of IRB application

Reference

Asselin G, Ward C, Penning JH, Ramanujam S, Neri R, (2012) Therapeutic Horse Back Riding of a Spinal Cord Injured Veteran: A Case Study, 37(6), 270-276

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Hamill D., Washington K. A., & White O. R. (2007). The effect of hippotherapy on postural control in sitting for children with cerebral palsy. Physical & Occupational Therapy in Pediatrics, 27, 23–42.

Kleinberg S. and Hripcsak G., A review of causal inference for biomedical informatics, Journal of Biomedical Informatics, 44(6), 1102-1112

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Miller J. H., & Alston A. J. (2004). Therapeutic riding: An educational tool for children with disabilities as viewed by parents. Journal of Southern Agricultural Education Research, 54(1), 113–123.

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Shurtleff T, Engsberg J (2012) Long-term effects of hippotherapy on one child with cerebral palsy: a research case study. British Journal of Occupational Therapy, 75(8), 359-366.

Silkwood-Sherer D., & Warmbier H. (2007) Effects of hippotherapy on postural stability in persons with multiple sclerosis. Journal of Neurologic Physical Therapy, 31, 77–84.

Figures

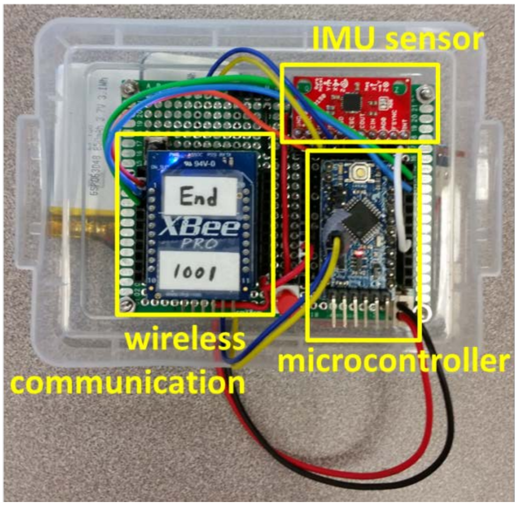


Figure 1. The first generation sensor. The size is about the size of credit card.

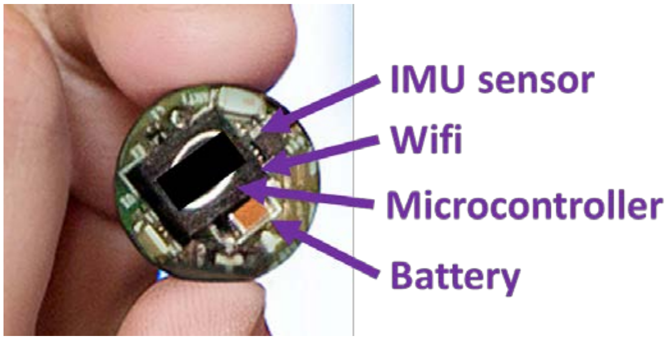
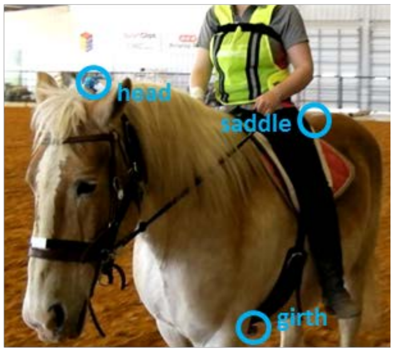


Figure 2. The second generation sensor. Its side is about the size of US quarter.

(a)



(b)

Figure 3. Wearable sensor locations for (a) the rider and (b) the horse.

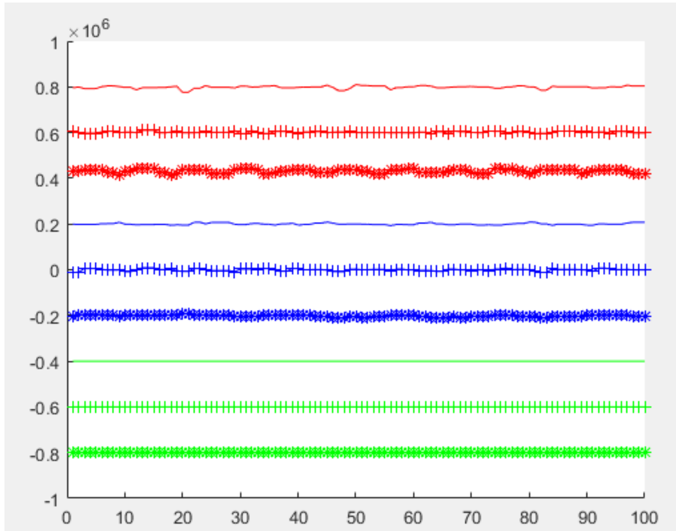
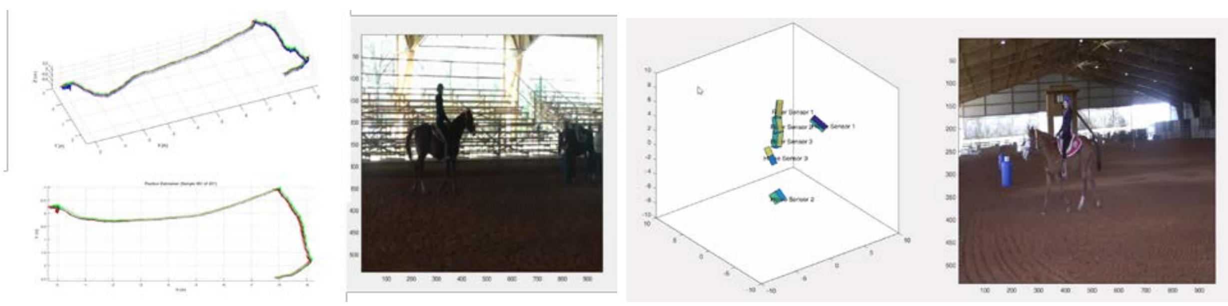
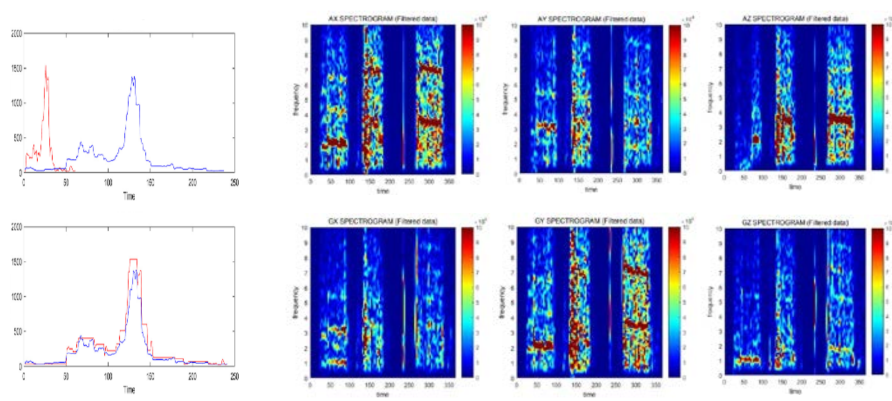


Figure 4. Real time raw data from each sensor. From top to bottom: $a_x, a_y, a_z, \omega_x, \omega_y, \omega_z, m_x, m_y, m_z$



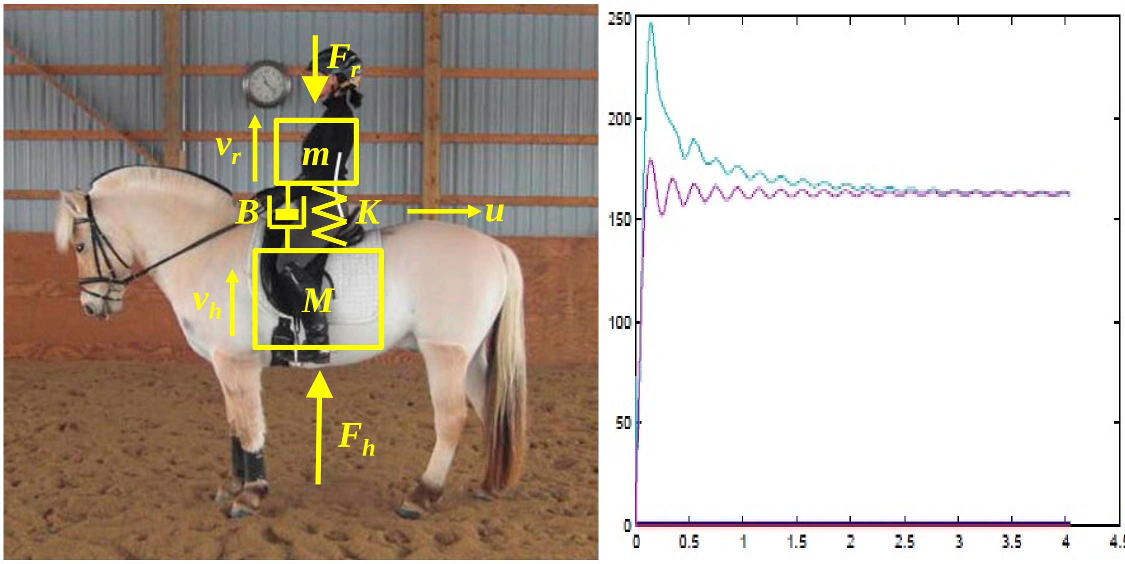
(a) (b)

Figure 5. Real time tracking of (a) horse position and (b) body orientation in 3D space.



(a) (b)

Figure 6. Coordination between the rider and horse. (a) Cross correlation plots with phase shift and (b) time-frequency plot



(a) (b)

Figure 7. Interaction between the rider and horse. (a) Mass-spring-damper model with detailed interaction forces and movement, (b) the movements of both the rider and horse are affected by each other due to the interaction.