

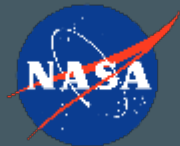


HCI International 2021
24-29 July • Washington DC, USA

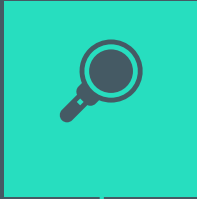


TAXONOMY OF PHYSIOLOGICALLY ADAPTIVE SYSTEMS AND DESIGN FRAMEWORK

John Muñoz, Luis Quintero,
Chad Stephens, Alan Pope



Contributions of this paper



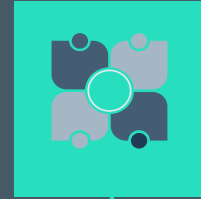
Review

Physiologically
adaptive systems
and their
computational
techniques



Taxonomy

Categorization for
biocybernetic
systems and
intelligent
adaptation



Design Framework

Aspects that must
be considered when
designing
physiologically
adaptive
applications

Problem

List of Physiological & Biometric Data

Eye Tracking and Pupil Response	Seismocardiography (SCG)	Intracranial Pressure (ICP)
Facial Scans	Phonocardiogram (PCG)	Electrocorticography (ECoG)
Electrodermal Activity (EDA)	Continuous Glucose Monitor (CGM)	Intracranial electroencephalography (iEEG)
Galvanic Skin Response (GSR)	Acoustic Respiratory Signals (ARS)	Deep Brain Stimulation (DBS)
Skin Conductance Response (SCR)	Blood Pressure (BP)	Local Field Potential (LFP)
Skin Conductance (SC)	Pulse Arrival Time (PAT)	Transcranial Doppler (TCD)
Skin Temperature (SKT)	Pulse Transit Time (PTT)	Somatosensory Evoked Potential (SSEP)
Body Temperature	Electroretinogram (ERG)	Brainstem Auditory Evoked Potential (BAEP)
Electromyography (EMG)	Electrogastrogram (EGG)	Functional Magnetic Resonance Imaging (fMRI)
Mechanomyogram (MMG)	Magnetogastrography (MGG)	Magnetic Resonance Imaging (MRI)
Strain-Based Sensor (SBS)	Electroencephalography (EEG)	Positron Emission Tomography (PET)
Electrocardiography (ECG / EKG)	Near-Infrared Spectroscopy-Based Cerebral Oximetry (NIRSCO)	Magnetoencephalography (MEG)
Heart-Rate Variability (HRV)	Optically-Pumped Magnetoencephalography (OP-MEG)	Nuclear Magnetic Resonance Spectroscopy (NMR or MRS)
Respiratory (RSP)	Optically-Pumped Magnetometers	Subdural EEG (sdEEG)
Respiratory Rate Variability (RRV)	Magnetoencephalography (OPM-MEG)	Intracranial EEG (icEEG)
Photoplethysmogram (PPG)	Time Domain Functional Near-Infrared Spectroscopy (TD-fNIRS)	Diffuse Correlation Spectroscopy (DCS)
Impedance Plethysmography (IPG)	Functional Near-Infrared Spectroscopy (fNIRS)	Subdermal EEG Needle
Blood Volume Pulse (BVP)	High-Density Diffuse Optical Tomography (HD-DOT)	Superconducting QUantum Interface Device (SQUID)
Electro-Oculogram (EOG)		
Impedance Cardiography (ICG)		
Gyrocardiography (GCG)		
Ballistocardiography (BCG)		
Magnetocardiography (MCG)		

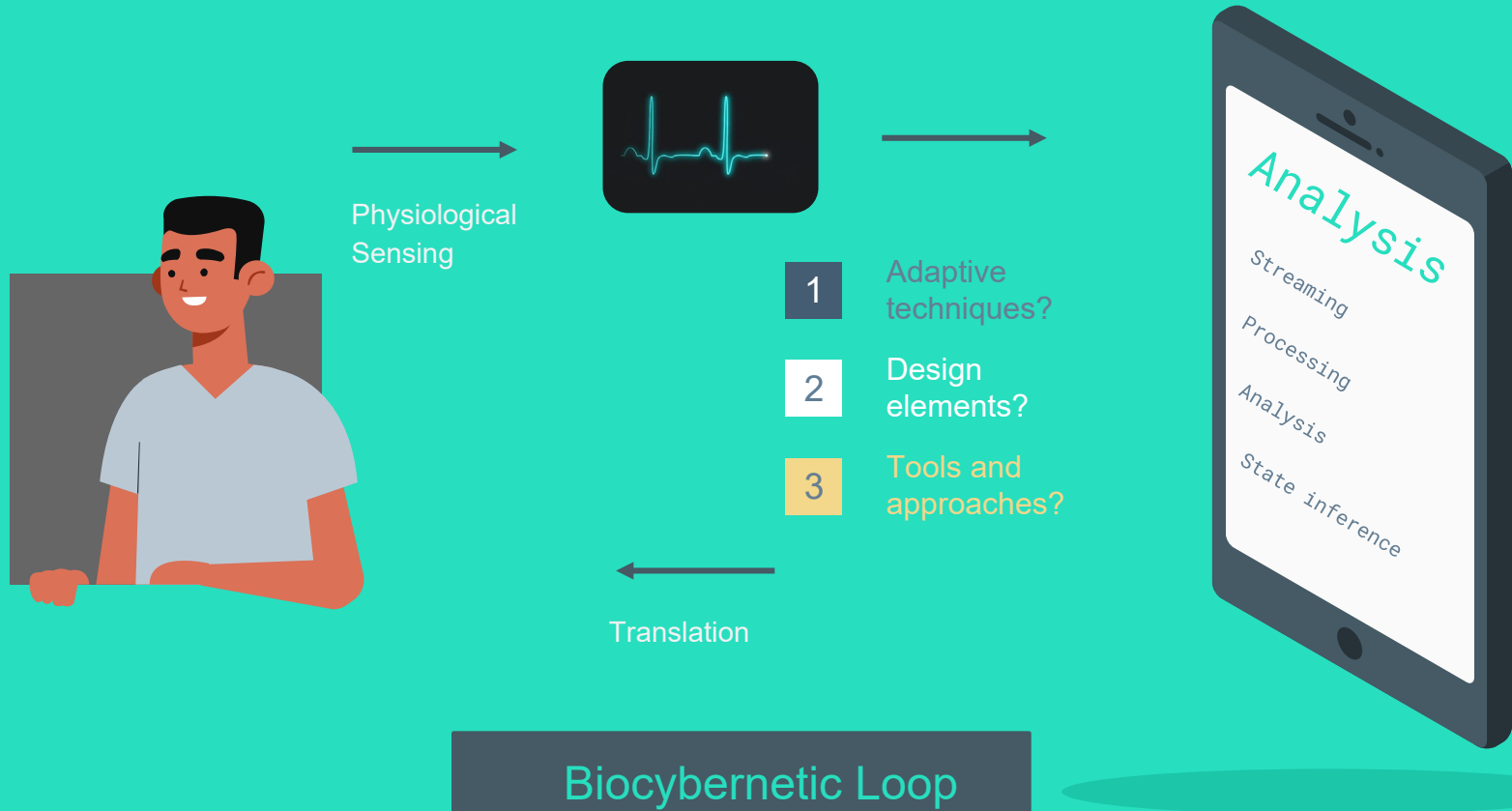
Bye, K. (2021, May 30). Twitter: <https://twitter.com/kendbye/status/1399143885427728384>.



?



Physiologically Adaptive Systems

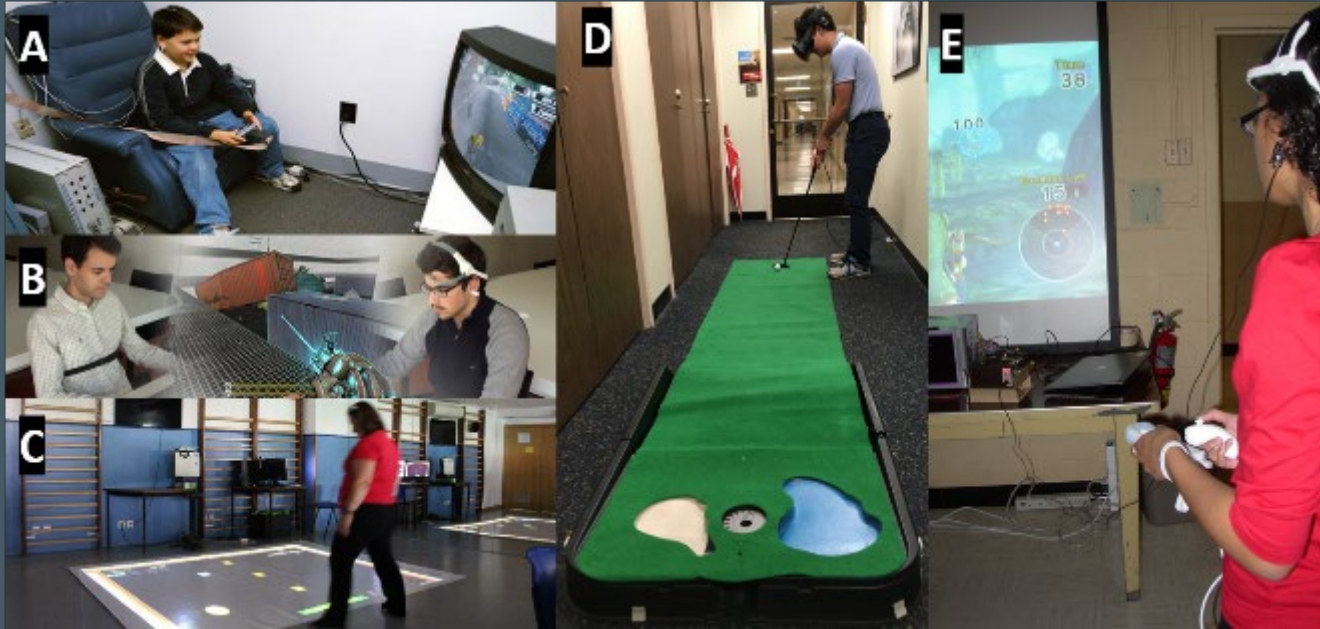


Review of Physiologically Adaptive Systems



- No systematic, but anecdotic
- Uses information from systematic reviews (Loewe 2020)
- Narrative around previously design systems and experiences
- Focused on the computational techniques for intelligent adaptation
- Comprehensive and illustrative

Results: Review



19

applications
and research
projects that
have
successfully
implemented
biocybernetic
loops

Results: Taxonomy



Control Theoretic

Closed - loop systems managing system inputs to drive the system to a desired target state

Machine Learning

Systems driven by responses of trained models using pattern recognition techniques

Classical

Well - established and grounded (e.g., On - Off, PID)

Modern

Adaptive controllers with more robust and stable techniques (e.g., dynamic threshold adaptation)

Supervised

Regression, classification

Unsupervised

Clustering, association

Reinforcement Learning

Interactive RL

Importance of the Taxonomy

Is Ganceable

Most of the adaptive systems have used classical controllers and machine learning is still scarce

Identifies Gaps

Proportional controllers are popular and ECG, EDA and EDA are the most used signals

Point out Needs

Reinforcement learning has not been used and data simulation can help

Has Examples

19 papers have been published demonstrating the use of physiologically adaptive systems

Results: Design Framework MAPA

● Medium

Means of communication where the adaptation will take place

● Application area

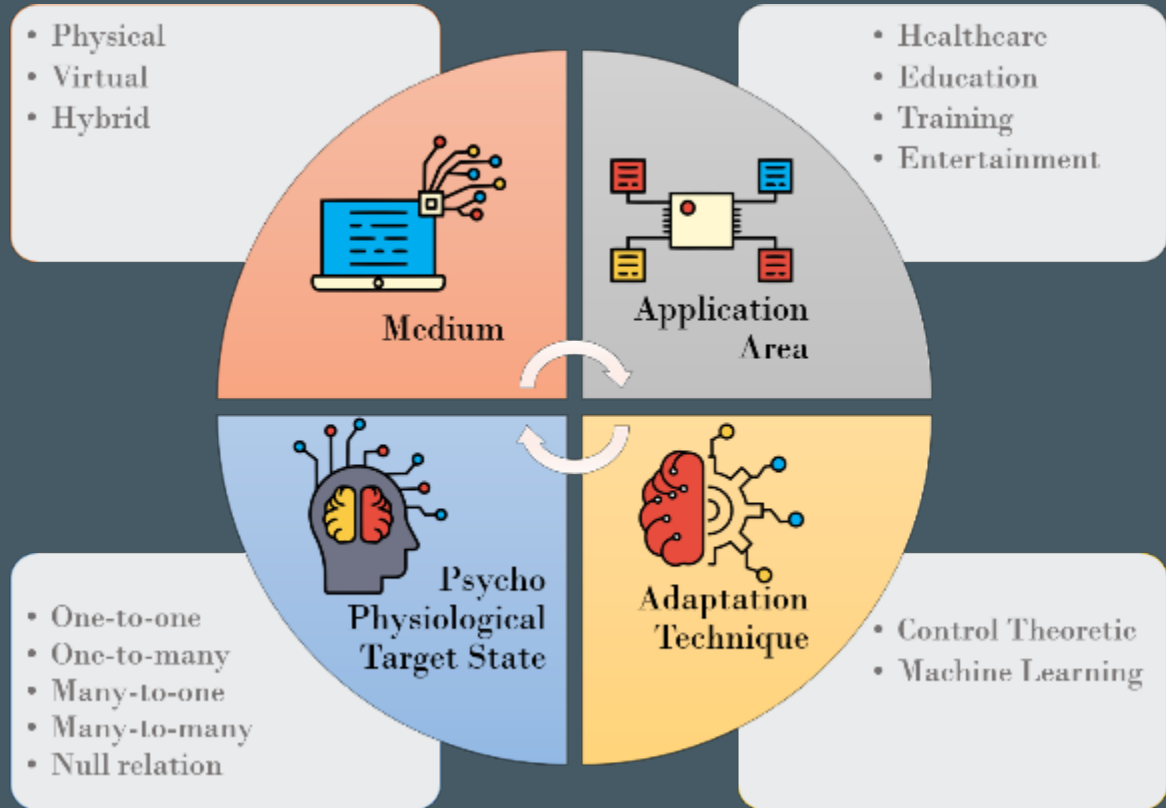
Context scenario or target application

● Psychophysiological State

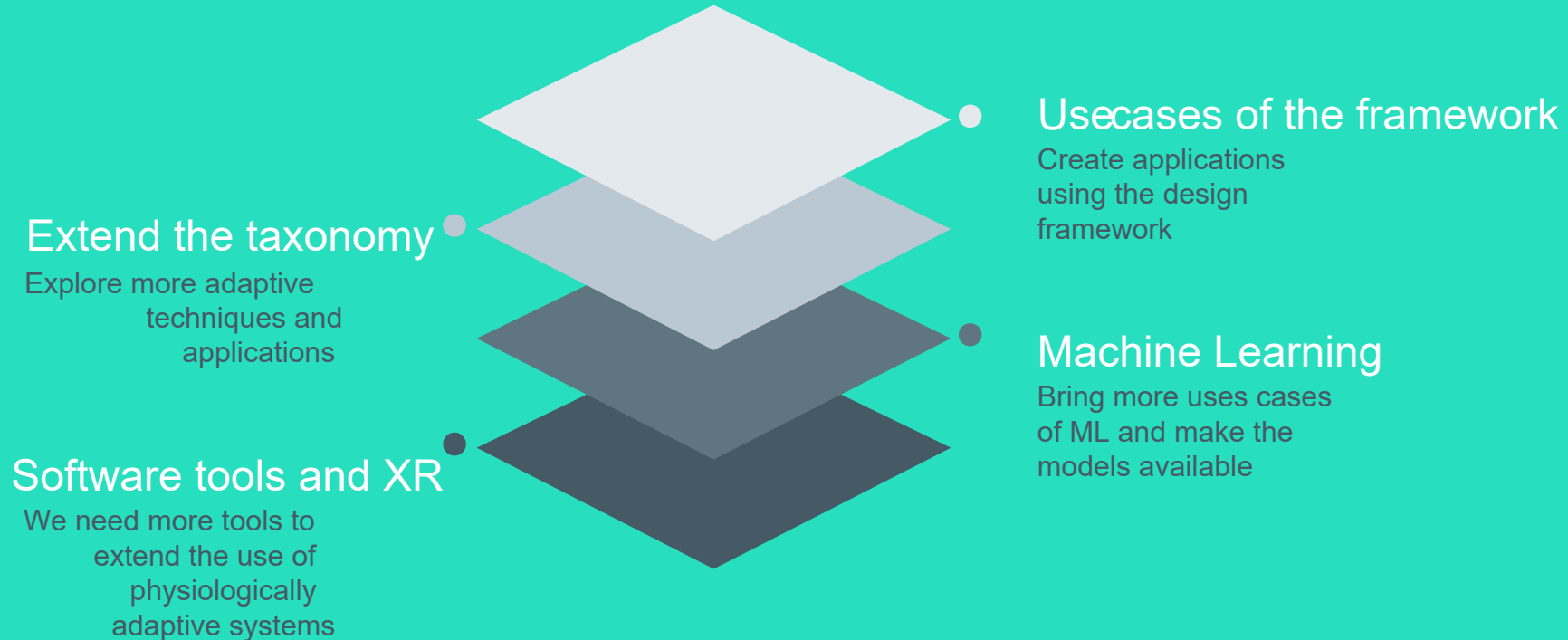
Human mental/physical state to infer and adapt the system

● Adaptation Technique

Type of computational technique used for adapting



Conclusion and Future Work



Thanks!

Do you have any questions?

john.munoz.hci@uwaterloo.ca
johnhci.com

CREDITS: This presentation template was created by **Slidesgo**,
including icons by **Flaticon**, and infographics & images by **Freepik**.