A Comprehensive Procedure for Personalized Happiness Recommender System

: Using Multi-Faceted Signal Processing with Holistic Quantified Self (HQS)

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Things to Make Clear

	X	O
Research Purpose	-Our purpose is **not** to make a system that **define happiness.** -Our purpose is **not** to **find an universal algorithm** that predicts happiness.	-Our purpose is to make a system that **boosts happiness** based on the collected 4 status and happiness level. -Our purpose is to **find a factor** that affects the **individual user's happiness**, and use the factor to recommend activities.
Happiness Measurement	Our system does **not predicts happiness** based on the 4 factors	Our system **directly measure happiness** by using **existing** Subjective Well-Being questionnaire (self-reporting)
Equation Purpose	**Not** to **define** happiness	To use it as a **recommendation basis**
Application	Our system does **not** apply the **same algorithm** to all users.	-Each user has **different algorithm** to be used to recommend activities. -Our system discovers the most relevant factors to the happiness level **for each user** because factors that are related to happiness is different **depending on each person.**
Duration	**Not** only **real time**	**Both long-term & real time** -Long-term tracking to find a factor -Real time recommendation (feedback) based on the factor

Research Objective

- Personalized Happiness Enhancing System
  - Support user with activity recommendation in real time
    - Analyze main factors that enhance happiness of each user
    - Recommend personalized activities based on that main factors

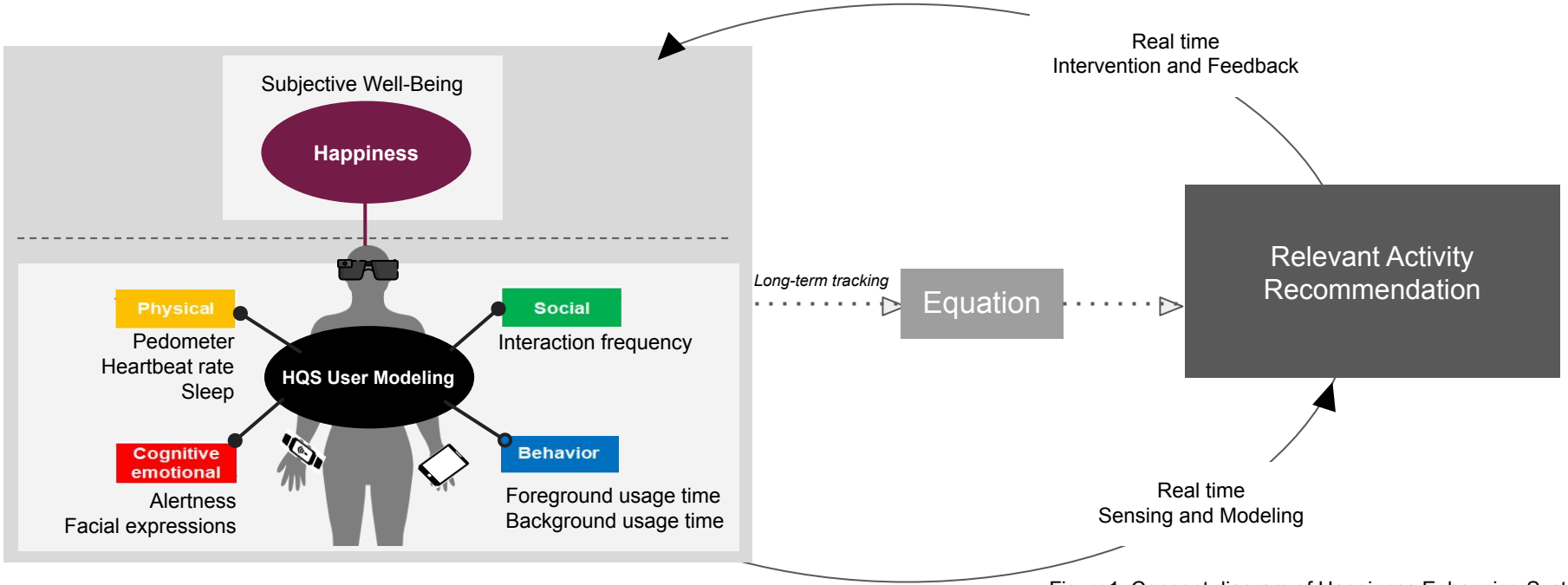


Figure1. Concept diagram of Happiness Enhancing System

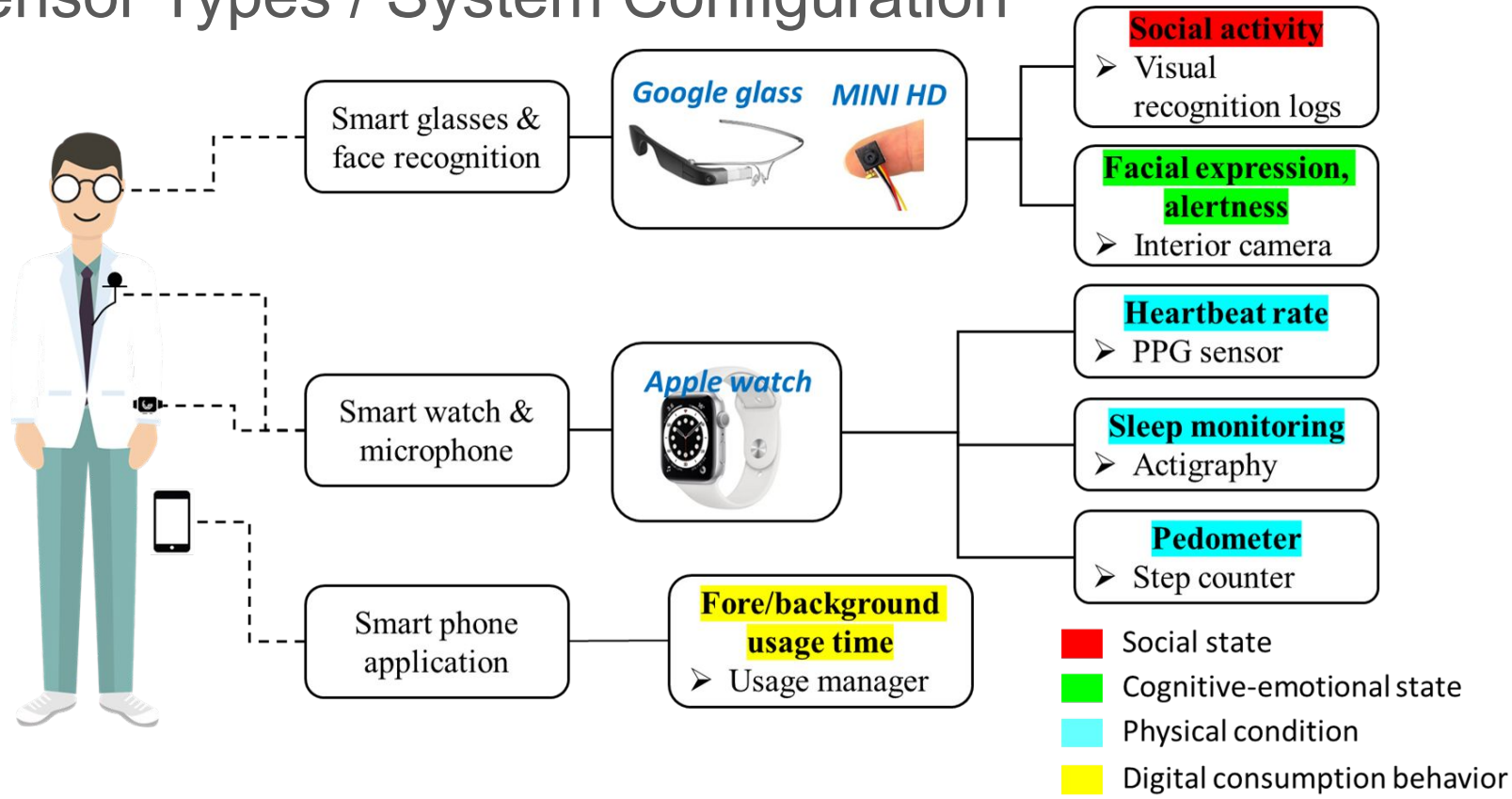
Implementation Detail(1/8)

- Definition of Happiness [1]
  - **Subjective Well-Being = Positive Affect + Negative Affect + Life Satisfaction**
    - Affect: pleasant and unpleasant mood and emotions
    - Life Satisfaction: a cognitive sense of satisfaction with life.
- Measurement of SWB
  - PANAS (Positive and Negative Affect Scale) [2]
    - 7 point scale
    - 10-10 items each affect
  - SWLS (The Satisfaction With Life scale) [3]
    - 5 point scale
    - 5 items

[1] Diener, E. (2009). Assessing subjective well-being: Progress and opportunities. Assessing well-being, 25-65.
[2] Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of personality and social psychology, 54(6), 1063.
[3] Diener, E. D., Emmons, R. A., Larsen, R. J., & Griffin, S. (1985). The satisfaction with life scale. Journal of personality assessment, 49(1), 71-75.

Implementation Detail(2/8)

- Sensor Types / System Configuration



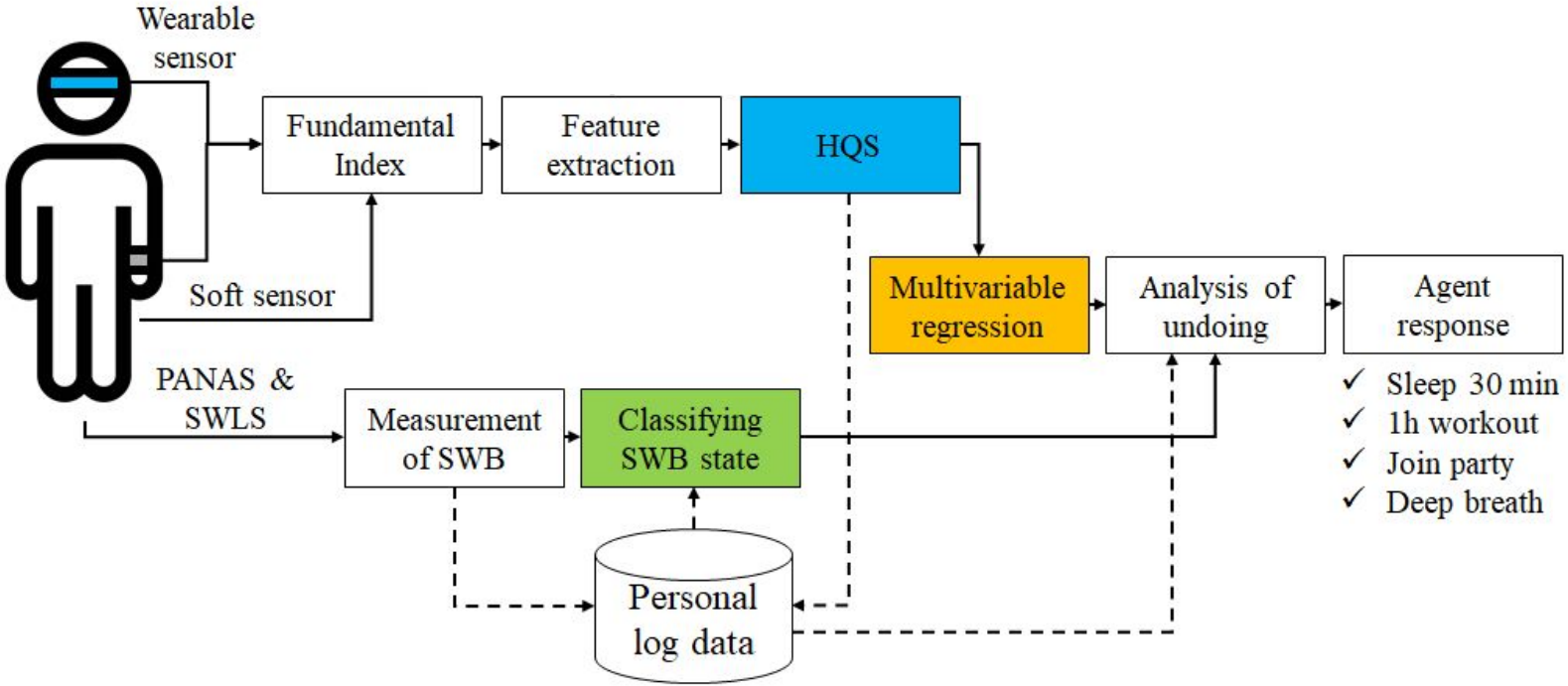
Implementation Detail(3/8)

- Data Acquisition Process

Sensor	Data type	Acquisition process
Google glass	Visual recognition logs	• Every 10 mins. • Waking hour
MINI HD	Facial image	• 2~20 mins. • Coupled with PPG sensor
Apple watch	Heartbeat rate	• 10~20 mins.
	Sleep state logs (Autosleep)	• Every 15 mins
	Pedometer	• Waking hour
Smart phone	Fore/background usage time	• Analysis of accumulated data

Implementation Detail(4/8)

- Flow Chart of Happiness Recommender System



Implementation Detail(5/8)

- Research Process

Implementation Detail(6/8)

- Research Process

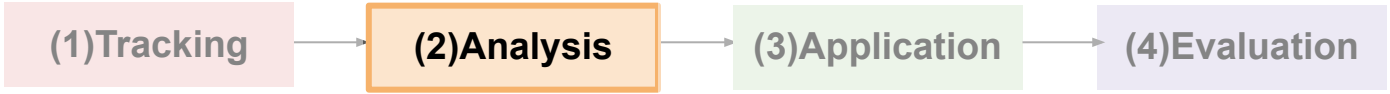
(1)Tracking → (2)Analysis → (3)Application → (4)Evaluation

  - Multifaceted tracking

Category	Fundamental index	Sensors
Physical condition	Pedometer	Step counter
	Heartbeat rate	PPG sensor
	Sleep	Actigraphy
Cognitive-emotional state	Alertness	Camera
	Facial expression	Camera
Social state	Interaction frequency	Visual recognition logs
Digital consumption behavior	Foreground usage time	Foreground activity logs
	Background usage time	Background service logs

Implementation Detail(7/8)

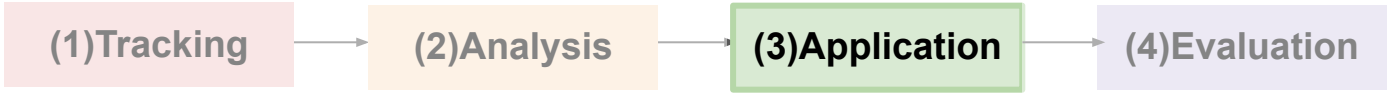
- Research Process



  - Multivariable Linear regression/ Correlation
    - Find factors that affect the user's happiness the most among 4 factors
    - $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_n x_n$
    - Ex. *Participant 1: Happiness = 45 + 0.1Cognitive + 0.2Physical +**0.3Social** + 0.1Behavior*

Implementation Detail(8/8)

- Research Process

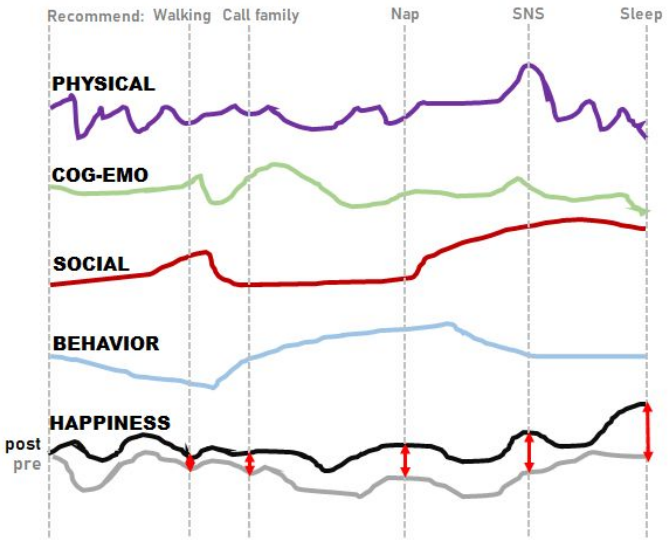


  - Use the equation obtained to create a recommendation system
  - If the user's happiness level decreases below a certain point, the agent recommend several related activity of the main factor.

Technical Evaluation & User Study(1/3)

- Research Process

(1)Tracking → (2)Analysis → (3)Application → **(4)Evaluation**

1. Visualization	2. User Study
	• Observe difference in happiness level • Draw conclusions about how useful this app is in boosting one's happiness

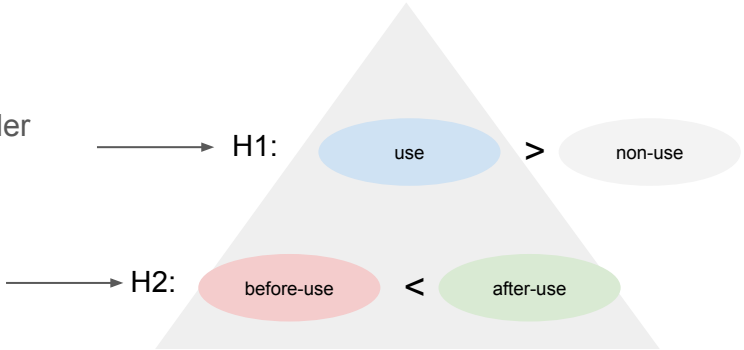
Technical Evaluation & User Study(2/3)

- Research Process

(1)Tracking → (2)Analysis → (3)Application → **(4)Evaluation**

- **Design**
  - 2 Independent variable
    - Whether the user use the Happiness Recommender (Non-using group, App-using group)
    - Time (Before-using condition, After-using condition)
  - 1 Dependent variable: Happiness level
  - Between subject design (Compare happiness level between Non-using group & App-using group)
  - Within subject design (Compare happiness level between Before using the app & After using the app)

- **Hypothesis**
  - H1: (between-subject difference)
    Happiness level of those who use Happiness Recommender will be significantly higher than those who do not use.
  - H2: (within-subject difference)
    For those who use Happiness Recommender, the user's happiness level will be significantly enhanced after using the app, compared to before.



- **Participant**
  - Clinically non-impared university students (Sample size = 40)

Technical Evaluation & User Study(3/3)

- Research Process

(1)Tracking → (2)Analysis → (3)Application → **(4)Evaluation**

- **Statistical Analysis**
  - Independent t-test (for comparison between Non-using group & App-using group)
  - Repeated Paired t-test (for comparison between Before-using condition & After-using condition)

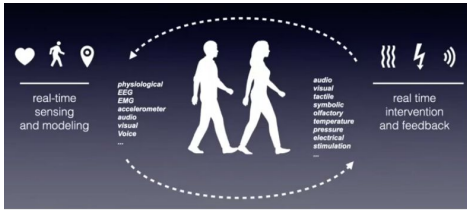
- **Expected Results**

Independent t-test (Non-using group & App-using group)					
① Happiness level of Non-use	3	1	2	1	2
② Recommendation	Walk	Call	Nap	SNS	Sleep
③ Happiness level of App-use	5	4	4	3	5
④ Difference between Non-use and App-use	2	3	2	2	3
⑤ Independent t-test					
⑥ Significance	$p < .05$	$p < .05$	$p < .05$	$p < .05$	$p < .05$

Paired t-test (Before-using condition & After-using condition)					
① *Pre*- Happiness level	3	1	2	1	2
② Recommendation	Walking	Call	Nap	SNS	Sleep
③ *Post*- Happiness level	5	4	4	3	5
④ Difference between Pre and Post	2	3	2	2	3
⑤ Paired t-test					
⑥ Significance	$p > .05$	$p < .05$	$p > .05$	$p < .05$	$p > .05$

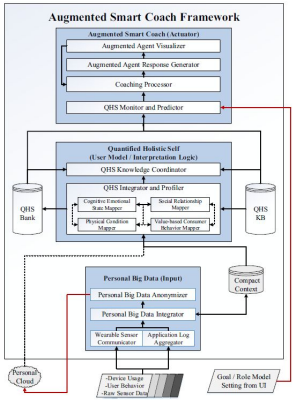
Literature Review (1/4)

- Comparison between Related Works

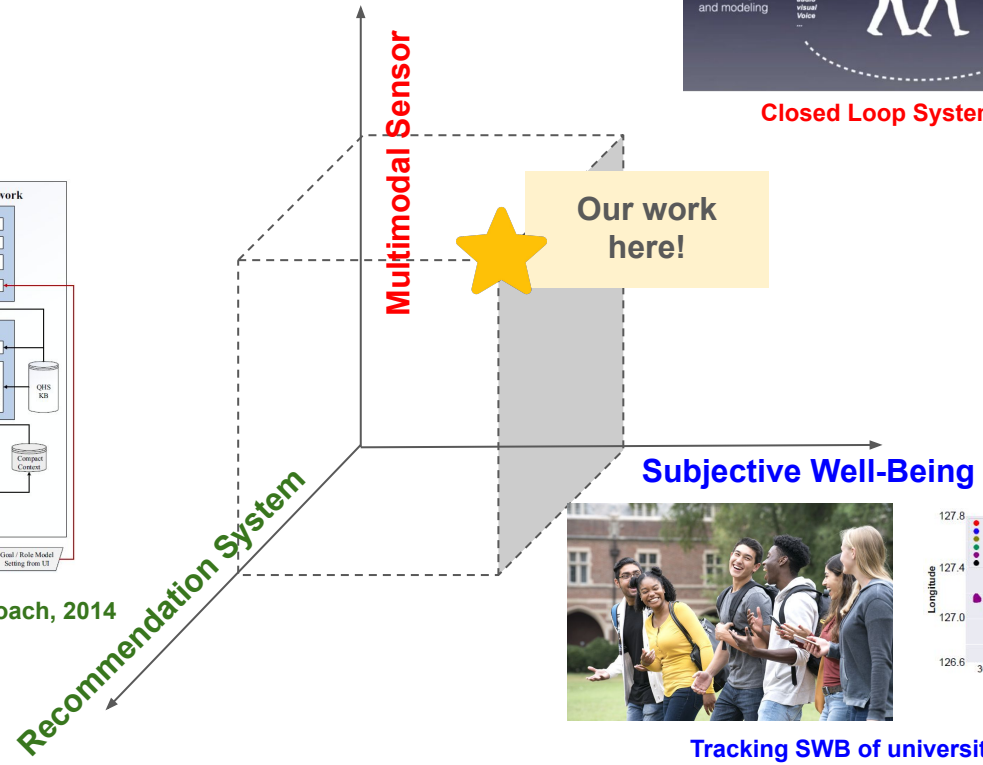


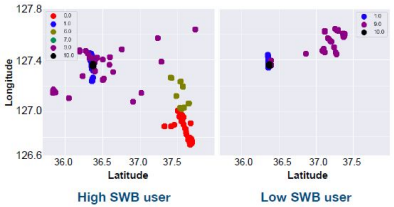
Closed Loop System, 2019

HQS Framework, 2018



/Augmented Smart coach, 2014





Tracking SWB of university student, 2020

Literature Review (2/4)

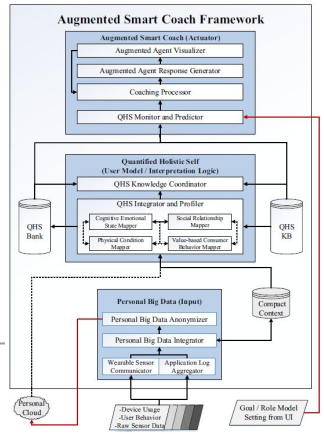
- **Subjective Well-Being**

Tracking SWB of university student, 2020	
Concept	• Comprehensive estimation / measurement system for SWB of university student • Prediction of salient factors for SWB by linear regression analysis • Capturing SWB changes by classification of COMOSWB survey results • Practical application using only smartphone sensor data   **Fig. 1** An example of GPS data in campus for high/low SWB user
Limitation	• System without biosignal sensor → low pearson correlation • No approach for supporting SWB
Novelty of Ours	• Emotion recognition by PPG / social relation by smart glass / sleep quality by actigraphy • Agent response giving optimal recommendation for boosting SWB by data analysis

[1] Rhim, S., Lee, U., & Han, K. (2020, July). Tracking and modeling subjective well-being using smartphone-based digital phenotype. In Proceedings of the 28th ACM Conference on User Modeling, Adaptation and Personalization (pp. 211-220).

Literature Review (3/4)

Recommendation

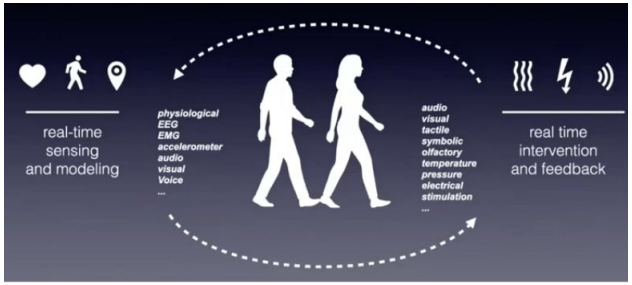
	HQS Framework, 2018 [1]	Augmented Smart coach, 2014 [2]
Concept	• First suggested the concept of HQS • Describing overall process of generating HQS 	• Suggested a framework for augmented smart coach • Proposed a coaching processor based on HQS generator • Application scenarios - Addiction prevention - Virtual life coaching - Happiness pursuer 
Limitation	• Limited to a conceptual framework • Made a prototype using just available trackers	• Limited to a conceptual framework • Limited to just a broad concept • No specific procedure for happiness pursuer
Novelty of Ours	• A step further toward a practical application from the framework • Make a prototype using available trackers based on careful consideration in order to represent the user's digital self	• Suggested a specific procedure for the happiness pursuer scenario • Evaluate how the augmented smart coach is effective in real life

[1] J. Lee, E. Kim, J. Yu, J. Kim, and W. Woo, "Holistic Quantified Self Framework for Augmented Human," In *International Conference on Distributed, Ambient, and Pervasive Interactions*,(2018, July).

[2] Yoon, H., Doh, Y. Y., Yi, M. Y., & Woo, W. "A conceptual framework for augmented smart coach based on quantified holistic self," *In International Conference on Distributed, Ambient, and Pervasive Interactions*, (2014).

Literature Review (4/4)

- **Multimodal Sensor**

	Closed Loop System, 2019[1]
Concept	● Wearables and immersive system supporting user with cognitive issues in real-time ● Sense what he is doing and what state he is in with all sorts of physiological sensing ● Analyze the data and help him with goals in terms of behavior change ● Give him real time feedback and intervention to help him develop cognitive skills 
Limitation	● Limited to tracking and solving only cognitive issues ● Unpractical EEG sensor based
Novelty of Ours	● Track not only cognitive state of the user, but also physical, emotional, social and behavioral state ● Use the holistic user data to give him real time recommendation ● Use practical sensors of smartphone for daily use with smart glasses, rather than unpractical EEG

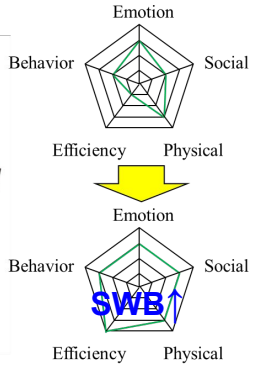
[1] Kosmyna, N., & Maes, P. (2019). AttentivU: an EEG-based closed-loop biofeedback system for real-time monitoring and improvement of engagement for personalized learning. *Sensors*, *19*(23), 5200.

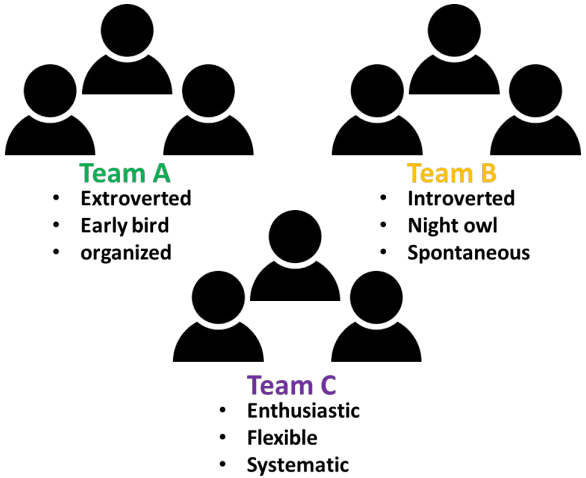
Contributions

- The first application utilizing HQS user modeling
- Realize an augmented happiness assistant enhancing human ability
- Propose a comprehensive procedure for generating personalized happiness recommender
- Solve disadvantages of conventional intervention
  - Eg. reading self-help books, watching courses, seeing a therapist or coach, and resorting to drugs
- In align with future Augmented Humans research directions
  - An interaction as integration, how could a system integrate with us in our daily life so it can help us
  - A system more as something that is always running and where the interaction can be initiated automatically by the state of the user and the context of the user
  - The systems could change over time and adapt with us and change with us the longer we use them.

Potential Application (1/2)

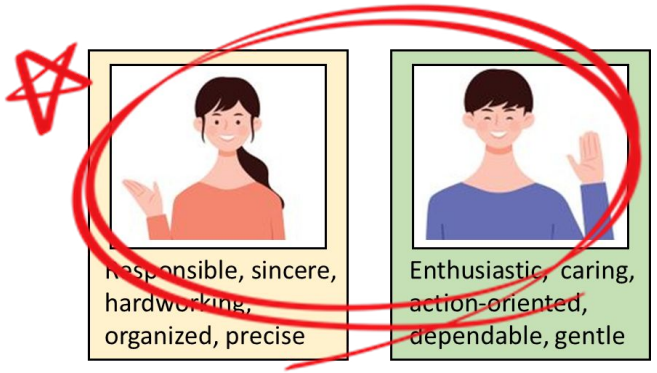
- Management of In-work Benefits & Team Building
  - Enhancing efficiency of work
    - Managing workload according to SWB
    - Elimination of main harmful factors
  - Designing building facilities
    - Arranging practical accommodation
    - Optimal illumination for enhancing SWB
  - Organizing team for optimal operation
    - Grouping similar chars. and business style
    - Deciding sustenance based on SWB variation

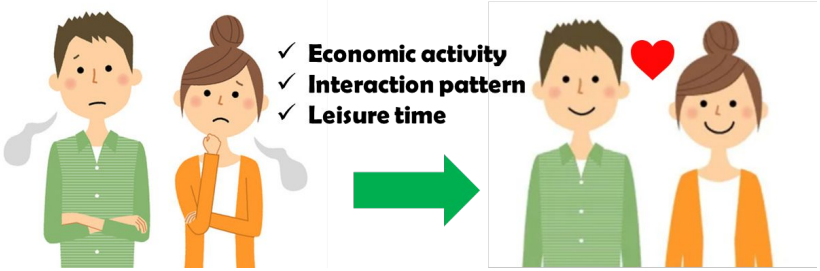




Potential Application (2/2)

- Commercial Dating Application
  - Collecting HQS database of date partners
    - Analyzing social interaction pattern
    - Grouping well matched characters
  - Blind-date matching system
    - To prevent break-up, classifying similar charcs.
    - Predicting probability of accomplishment
  - Couple management
    - Diagnosing relation by SWB state
    - Analysis of factors for break-up
    - Giving a feedback for sustenance





Thank you

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