穿戴式系統與互動媒體藝術：理論、技術與案例研討

廖峻鋒

{cfliao}@nccu.edu.tw

資訊科學系 & 數位內容學程

國立政治大學

Outline

- 背景
  - 數位內容 (Digital Content & Technologies)
  - 數位互動藝術 (Interactive Art)
  - 穿戴科技 (Wearable Systems)
- 利用穿戴科技支援數位藝術展演
  - 平台軟硬體 (WISE)
  - 展演腳本編寫 (DIPS)
  - 實務應用案例

數位內容學程簡介

- 基於政大社會人文深厚根基開拓新藍海
  - 傳播學院與資訊科學系合辦
  - 培育數位內容之創造、資訊設計、科技實作、企劃及系統開發跨領域人才
  - 2009年成立碩士學程，2011年成立學士學程
  - 具專屬空間、獨立員額與系院級教評會
- 發展主軸
  - 數位敘事、數位文創、使用者經驗設計、智慧環境
- 教師組成
  - 主聘員額8位，傳播學院與資科系各聘4位，亦需負責原聘系所教研工作
  - 課程支援老師來自傳院與資科系
  - 許多課程(含碩士論文與與大學畢展)由雙領域老師「共同」授課

數位內容學程簡介

- 學生組成
  - Living Lab數位互動創作實驗室: 開放全校參與
    - 提供有興趣同學在申請前進行先期訓練與方向探索
  - 大學部:以雙主修方式公開招考，需交學分費
    - 需額外繳費，學生對教學品質要求高
    - 2/3學生修習前不具程式能力
  - 研究所:獨立招生，管道與一般研究所相同
    - 錄取率 6~10%
    - 考取學生中大約1/2為非資訊相關科系畢業
    - 論文需為跨領域、雙指導

數位內容學程簡介

- 課程特色
  - Digital content creation
  - Comprehensive execution ability
- 研究方向
  - 數位敍事、數位文創、使用者經驗設計、智慧環境

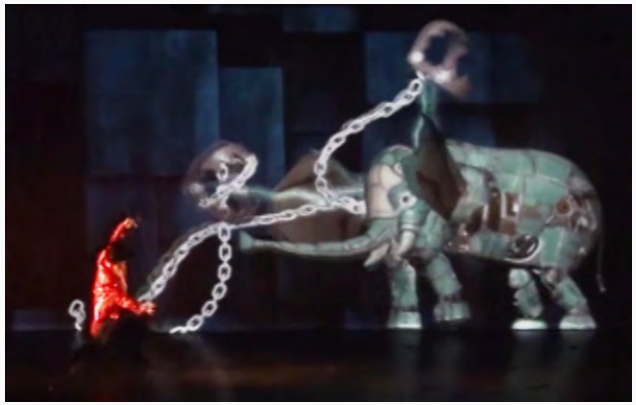


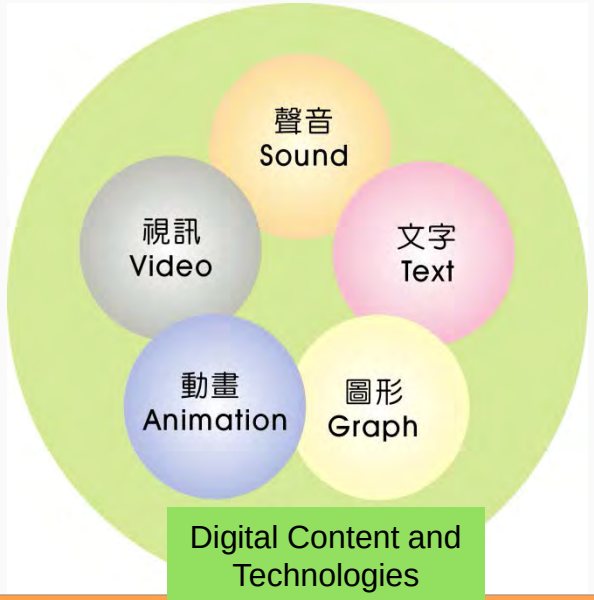




什麼是數位內容 (DCT)

- Cultural and Creative Industry
  - Origin in individual creativity, skill and talent and which have a potential for wealth and job creation
- Digital Content and Technologies (DCT)
  - Any content exists in the form of digital data
  - The technologies manipulate and present the digital content





Digital Content as “New” Media

- Artworks in New Media are usually interdisciplinary (Chiu，2016)
  - Applications of new technologies
  - Wisdom of art and creativity
  - Recognition of daily lives
  - New use of old material
  - Must be created with aesthetic perception

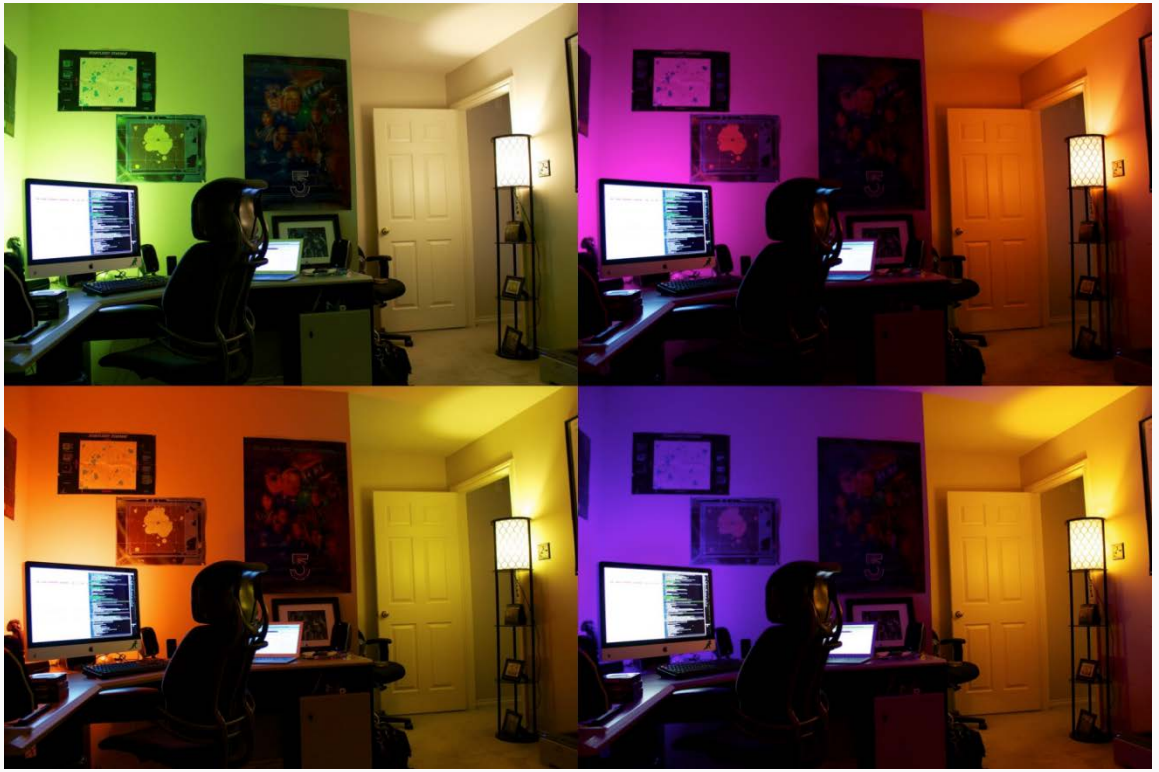
Applications of DCT

- Commercial activities
  - Training materials
  - Marketing / product promotion
  - Smart office
  - Concert

Crowd Painting https://www.youtube.com/watch?v=hYnaMaKj27M (1:00)

Applications of DCT

- Smart Environments
  - Smart Home
  - Game
  - Immersive movies



Applications of DCT

- Education
  - Digital teaching materials
    - E-books
    - Multimedia
  - Teaching aids
  - MOOCS

Applications of DCT

- Public art
  - Huang(2013): The moment we meet
  - Taipei Metro, Taipei 101 station

The art installations use early split-flap displays to form 10x10 matrixes of faces. Every single display can be controlled independently and create endless number of combinations of faces.

Categories of Digital Content

- Canonical digital content
  - Digitalized data such as text, images, video, animation (or the combination of them)
- Hypermedia
  - Inter-referenceable digital content
- Interactive digital content (Interactive Art)
  - The contents change by reacting to audience behaviors

Interactive Art

- Mediated by digital contents and technologies
- Factors
  - Installation
  - Audience
  - Visualization
  - Interpretation
- Audience's role
  - to/not to act
  - to/not to be represented

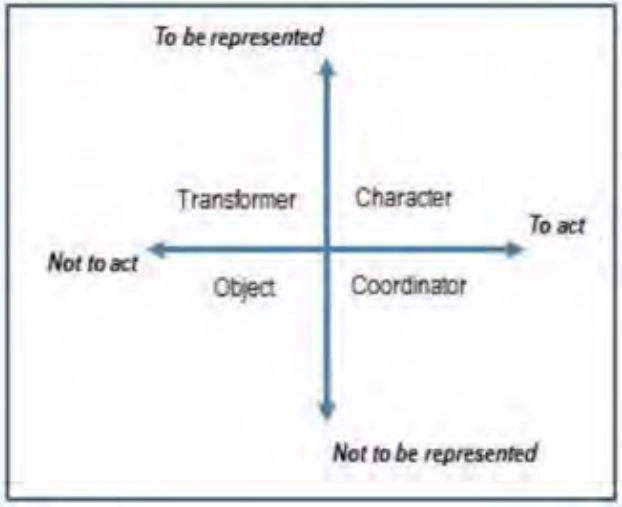
Oh and Shi (2013)

To act' Type, Jeffrey Shaw, Legible City, 1989-1991

To be represented' Type, Herman Maat, Paranoid Panopticum, 1999

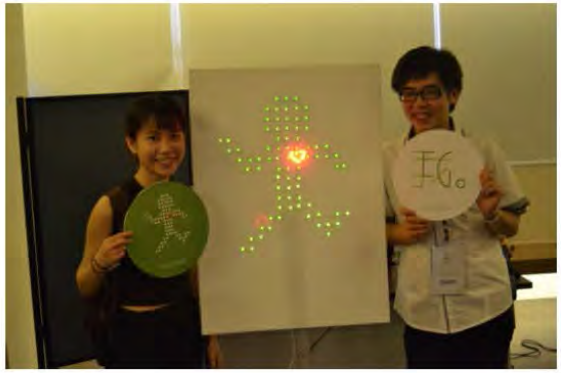
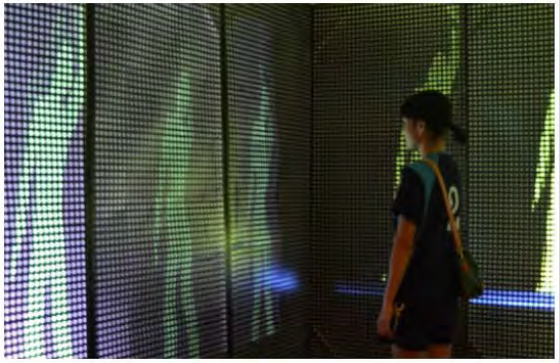
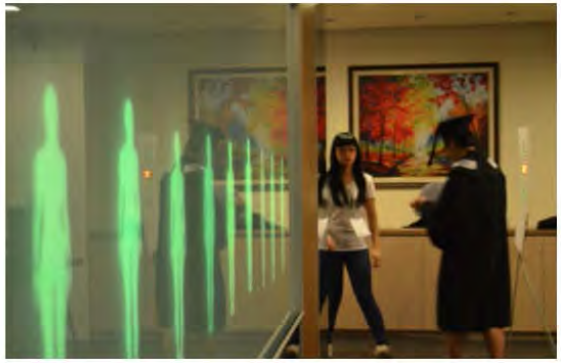
Audience's Role

- Character
  - to be represented (by the audience)
  - to act (to react to the audience)
- Coordinator
  - not to be represented (by the audience)
  - To act (to react to the audience)



Character Type

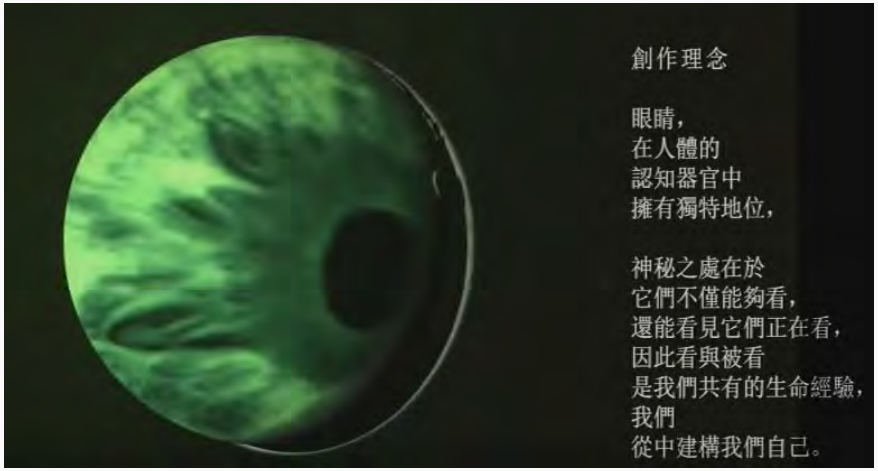
- Lin et al. (2014) :Let Ego Dance
  (NCCU DCT Students)

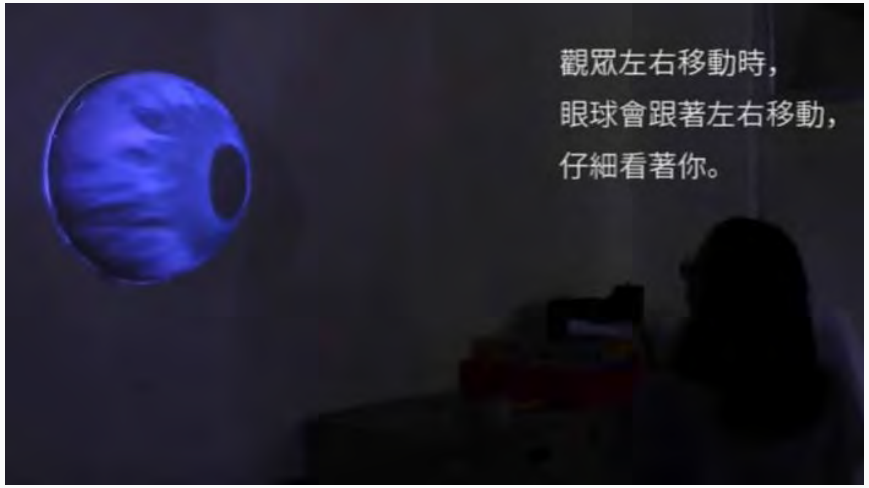





Coordinator Type

- Li et al. (2015): iContact

  (NCCU DCT Students)





https://drive.google.com/file/d/0B7Swyd5BNorUR2h1WGRiMzBmdXc/view

Not to be represented (by the audience)
To act (to react to the audience)

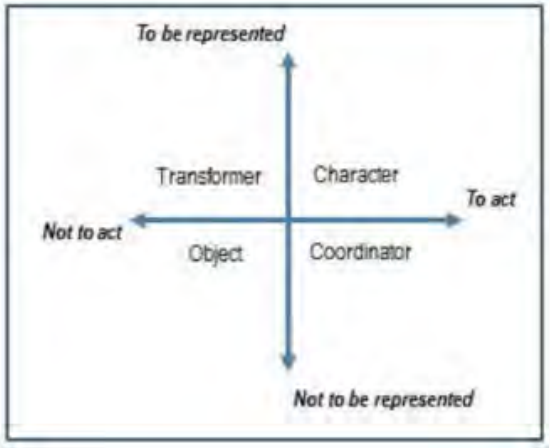
Coordinator Type

- Break the wall (2013)
  (NCCU DCT Students)

Not to be represented (by the audience)
To act (to react to the audience)

Audience's Role

- Transformer
  - The installations represents the audiences (to be represented)
  - The installations do not react to audiences' behaviors (not to act)
- Object
  - The installations do not represent the audiences (no to be represented)
  - The actions of installations do not reflect audiences' actions (not to act)



Object Type

- 姚紀徽(2016): Whispers from the sea
  (NCCU DCT Students)

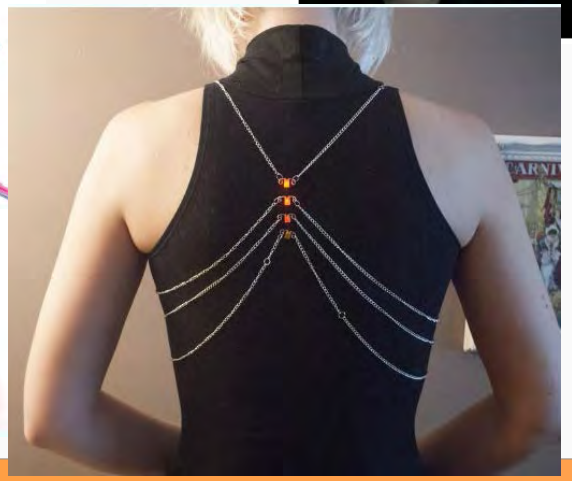
Wearable Systems

Wearable Systems

- 定義
  - 可穿戴在人(或動物)身上的計算裝置
  - Useful for application the require computational support while user's hands, voice, eyes, arms or attentions are actively engaged

穿戴系統的應用

- 設計
  - Blueprints, etc.
- 製造業、工廠、建築施工
  - Access to information given by remote experts
- 軍事
  - Soldiers monitoring health, equipment, etc.
  - Maps and terrain
- 學術研究
- 醫學研究
- 時尚產業
  - fashion tech



穿戴式系統

- 1994 First modern day wearable system
  - Thad Starner and Steve Mann
  - Transmitting images from a head camera to the Web
- Envisioned:
  - portable and wireless
  - easy to use (不需要太多efforts)
  - augment human perception
  - have awareness of the physical environment

Xybernaut (1993)

- One of the first commercial wearable solutions
  - belt-attached computing block and a carry-on display

比較近期的款式

(1993) Hip-PC

- Intel 80286 processor
- HMD (Private Eye)
- handed keyboard (Twiddler)

IBM Linux Watch/Q-Belt

- Integration of a complete computing system into a wrist-worn device, presented in 2000
- ETH Zurich introduced QBIC for use in research and as a design study in 2004

WearARM (2001)

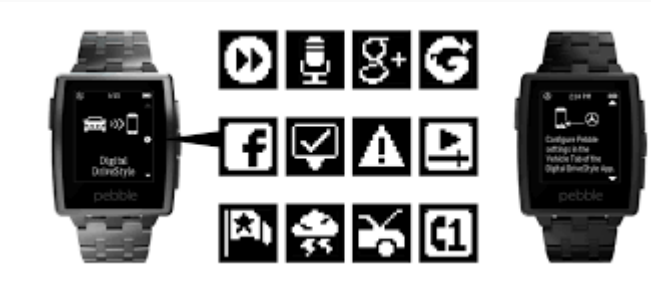
- Clothing-attached electronics
  - A flat profile wearable computer that used flex-print technology to interconnect components.
  - Introduced by ETH Zurich

MIThril (2003)

- Hardware platform
  - Body-worn computation, sensing, and networking in a clothing-integrated design
- Software platform
  - A combination of user interface elements and machine learning tools built on the Linux operating system.

現代穿戴系統的發展(2010~)

- Ecosystem of connected devices
  - 硬體快速進展，微小化「電腦」已成為普及技術
  - 各裝置相互連結、資料分享
  - 新型態裝置加入，就會產生新的互動效果
    - 例1: Tablets 成為 TV的第二螢幕
    - 例2: Mercedez-Benz: Digital Drive Style app



Current Wearable Applications

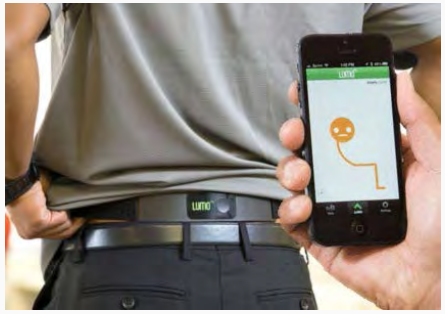
- 運動與健身紀錄
  - Wristbands or clip-on trackers that collect activity data
    - steps taken
    - calories burned
    - stairs climbed
    - distance traveled
    - hours slept

Current Wearable Applications

- 娛樂應用: Disney MagicBand+MyMagic+
  - provides guests with access to their hotel room, theme park, FastPass+ selections, and PhotoPass
  - Can be linked with a payment account, serving essentially as a personal identifier
  - This wearable works in collaboration with My Disney Experience website and mobile app with which guests can plan their trip and access the latest information on Walt Disney World Resort.

Current Wearable Applications

- 健康與醫療感測器
  - Monitors physiological status, including heart rate, respiration rate 呼吸, ECG, temperature, emotional stress, dehydration脱水, glucose level血糖, and posture 姿態



Zephyr's BioHarness

Metria IH1

Lumo Back

Nuubo's nECG

應用:智慧型個人健康檢視系統

心率變異

血壓

體重

活動程度

一段時間的生理
及活動資訊

結合醫學知識與
人工智慧技術的
機器學習演算法

階段一：資料搜集

階段二：建立個人專屬健康狀況模型

自主神經功能
心血管功能
體重穩定度
晝夜節律

個人專屬健康狀況模型

應用:智慧型個人健康檢視系統

階段三：即時自我健康檢視

心率變異

血壓

體重

活動程度

自我健康檢視介面

自主神經功能
心血管功能
體重穩定度
晝夜節律

個人專屬健康狀況模型

健康狀況與異常徵兆

Current Wearable Applications

- 智慧手錶

Samsung Galaxy Gear

Pebble watch

Moto 360

Current Wearable Applications

- 智慧眼鏡與VR

GlassUp AR

Google Glass

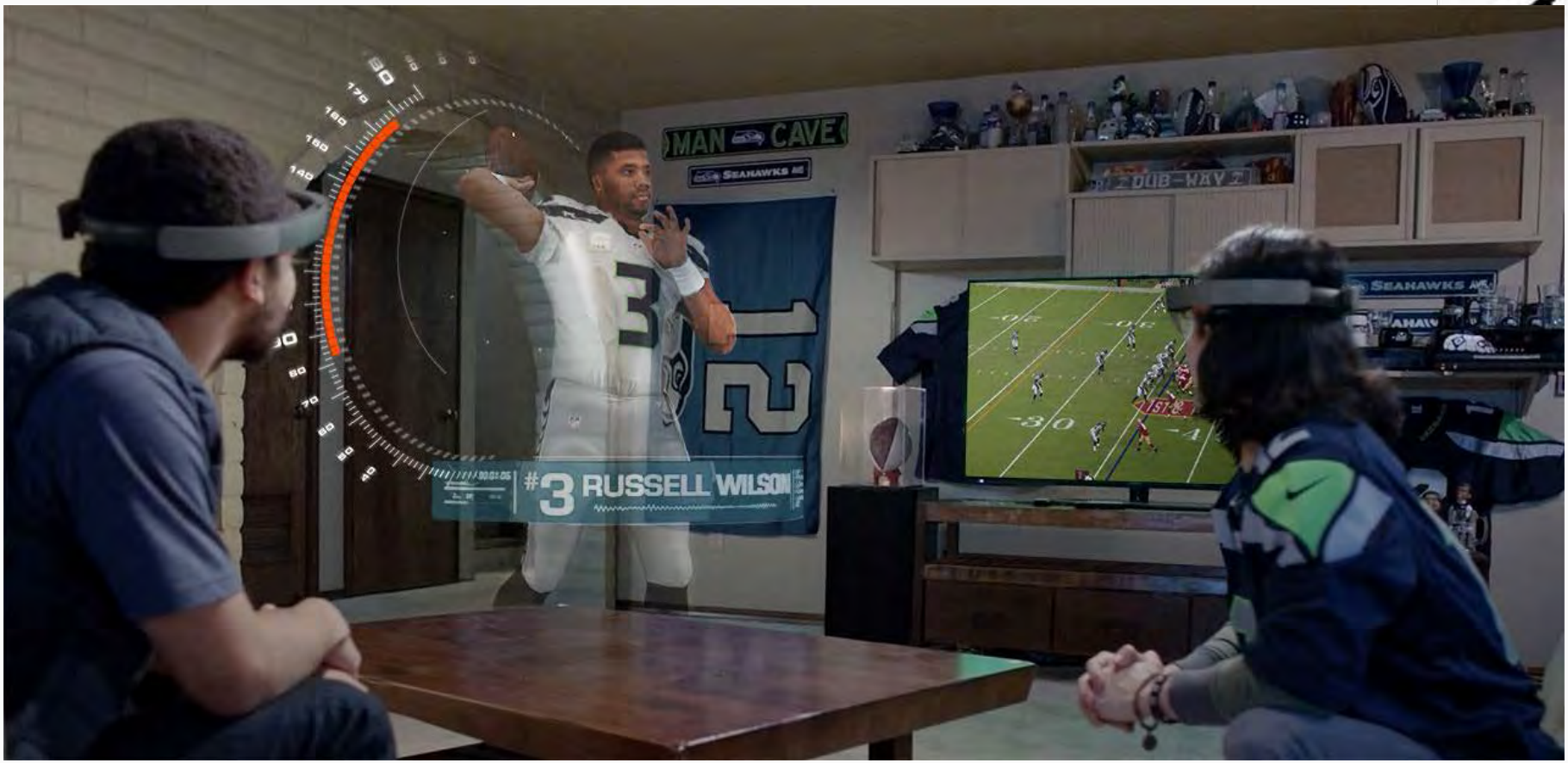
Vuzix M100

Meta AR

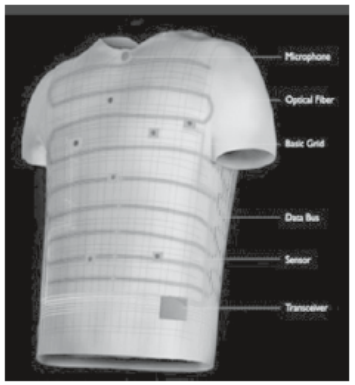
Oculus Rift

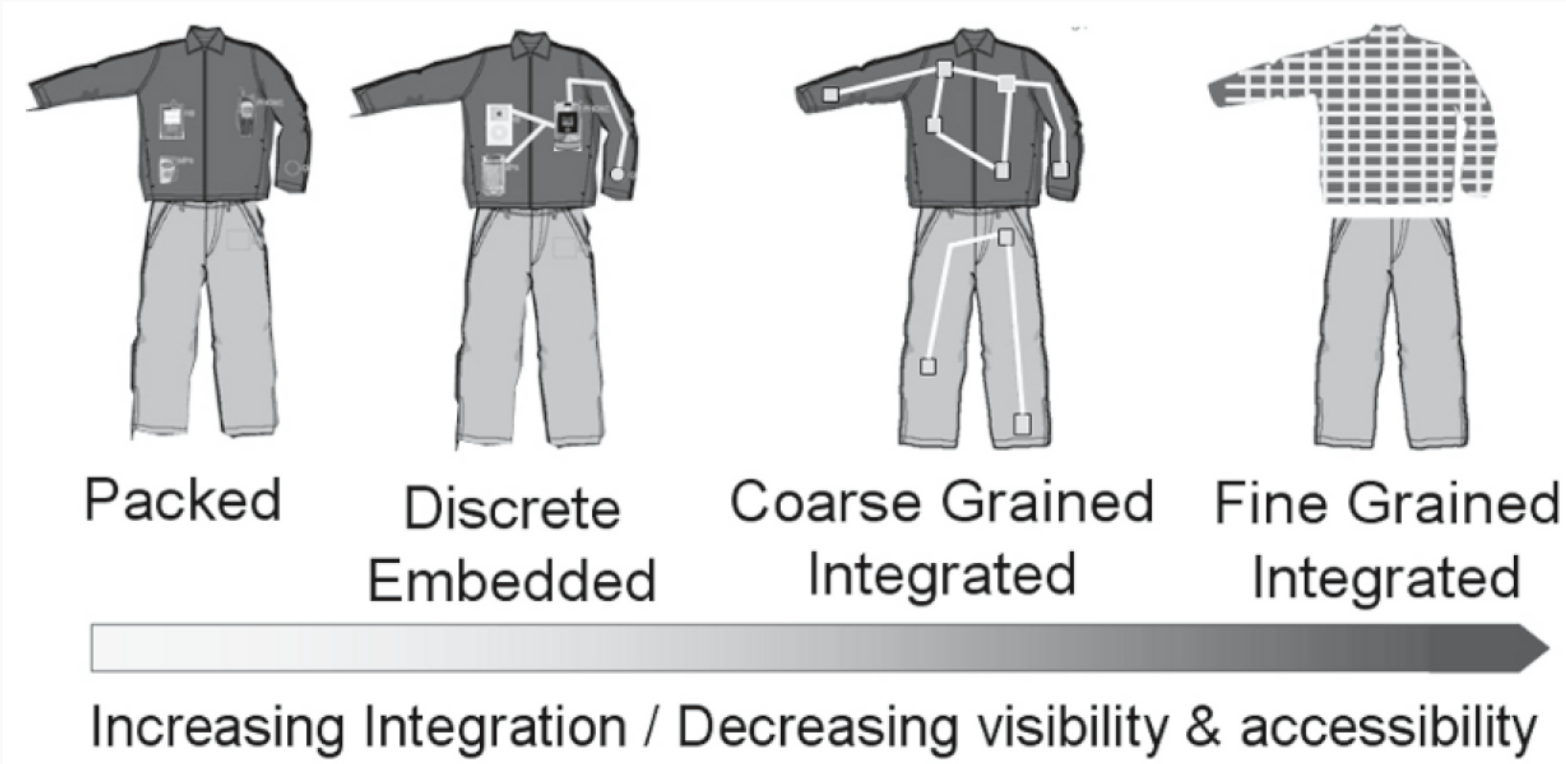
CastAR

Microsoft Hololens



穿戴系統與智慧衣物


Microphone
Optical Fiber
Basic Grid
Data Bus
Sensor
Transceiver


Packed
Discrete
Embedded
Coarse Grained
Integrated
Fine Grained
Integrated
Increasing Integration / Decreasing visibility & accessibility

穿戴系統與智慧衣物

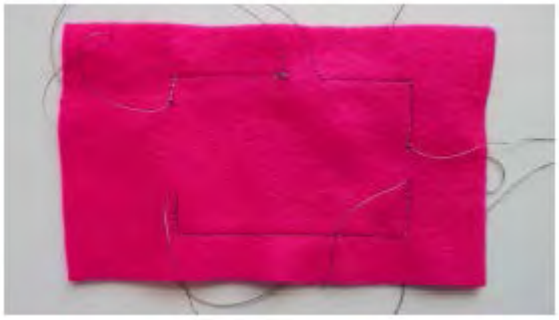
- Athos健身服佈滿了感測器，可偵測胸、肩、手、背、股等肌肉運動與呼吸、心跳
- 重要設計原則
  - 保持簡單 (容易操作與維修)
  - 一體成形 (容易穿上)

Athos smart workout gear

Touchscreen T-Shirt

穿戴式電子材料

- 導電縫線
  - thread that contains conductive metals, such as silver or stainless steel



MIT Musical Jacket

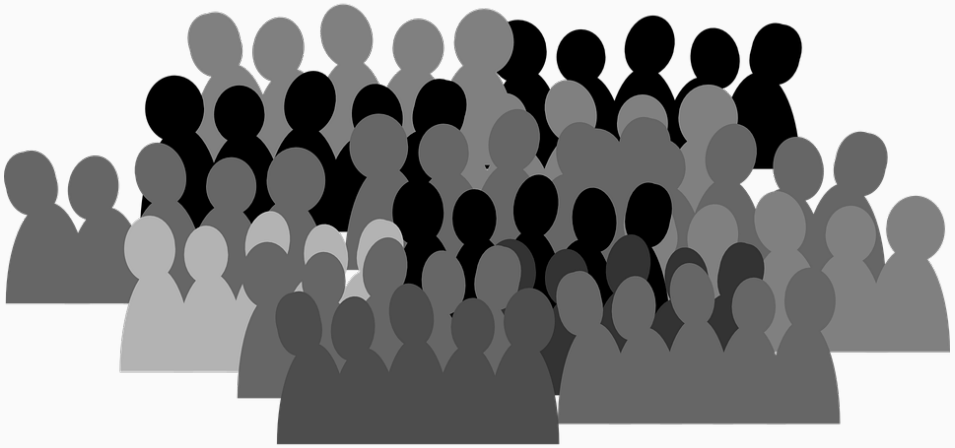
Becky Stern's "A Tribute to Leah Buechley"

註: Leah Buechley是Lilypad的發明者

Supporting Interactive Performance Art

創作: 黃心健、連俊傑、陶亞倫、柯智豪、黃凱宇

React to the performer



no to be represented

not to act

Credit

- 本演講提及技術主要來源
  - 科技部: 穿戴式互動展演創新應用與技術研究
- 研發團隊 (政大數位內容學程)
  - 主持人: 資科系 蔡子傑
  - 共同主持人:
    - 資科系: 李蔡彥、陳恭、張宏慶、廖文宏、余能豪、廖峻鋒
    - 傳播學院: 陳儒修、黃心健、陶亞倫

Introduction

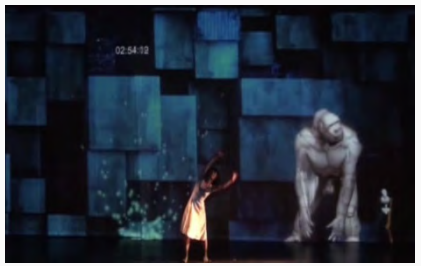
- Performance has become the main source of profit in the Cultural & Creative Industries
- Interactive performances provide new experiences
  - Creative combination of new technologies and digital content
    - Computer animation
    - AR/VR
    - Wearable technology
    - Robotics

Light and Tap Croatian Rhapsody (2014)
(NCCU DCT Students)

https://www.youtube.com/watch?v=KJJdm95wfR8

Introduction

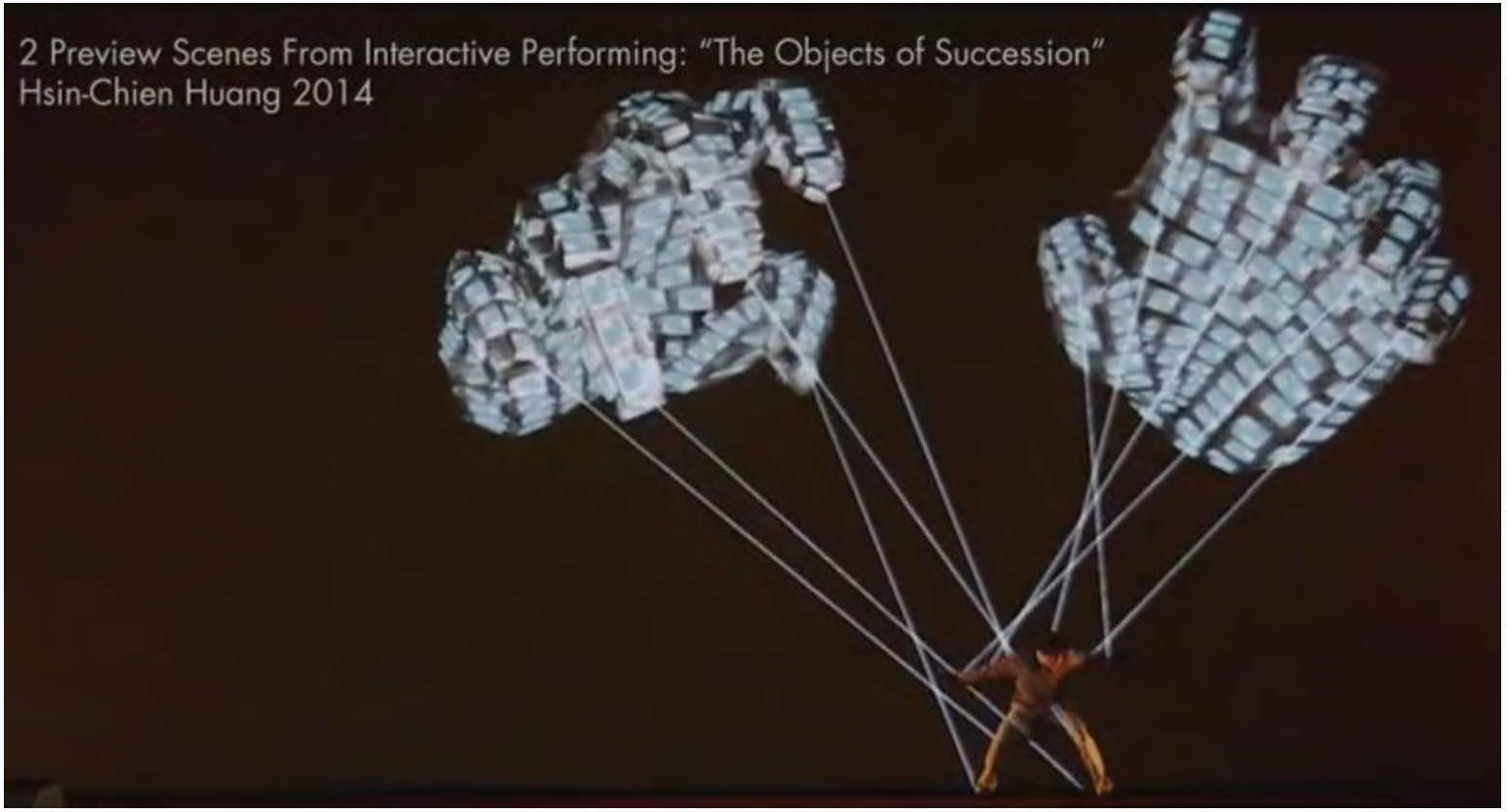
- Mixed-reality interactive performance art
  - Performance carried out by both real and virtual performers
- Traditional
  - Play animations/effects in pre-determined way
  - Deprives the “liveness” of performers
- Performer-guided
  - Define how animations/effects react to performer’s postures
  - Ad hoc performance guided by real performers



Introduction

Performer-guided mixed-reality

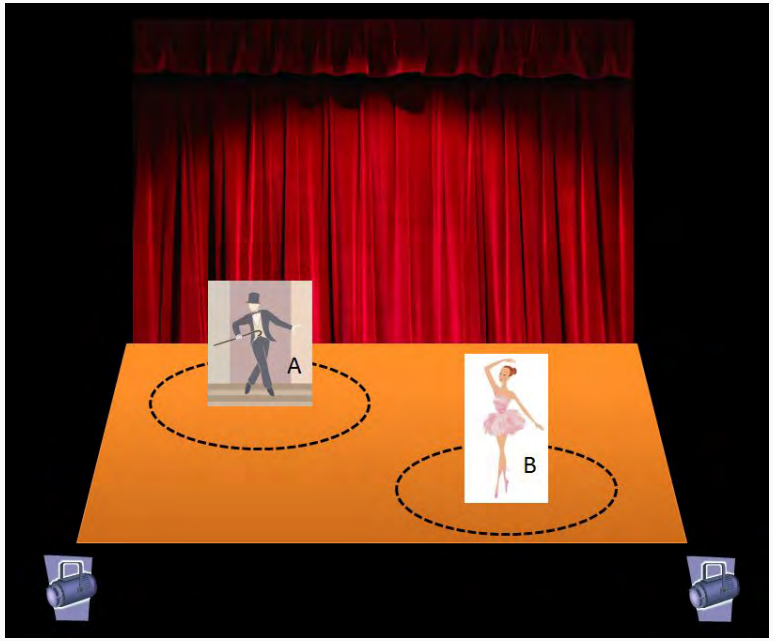
(Created by NCCU DCT Faculty, Prof. H.-C. Huang)



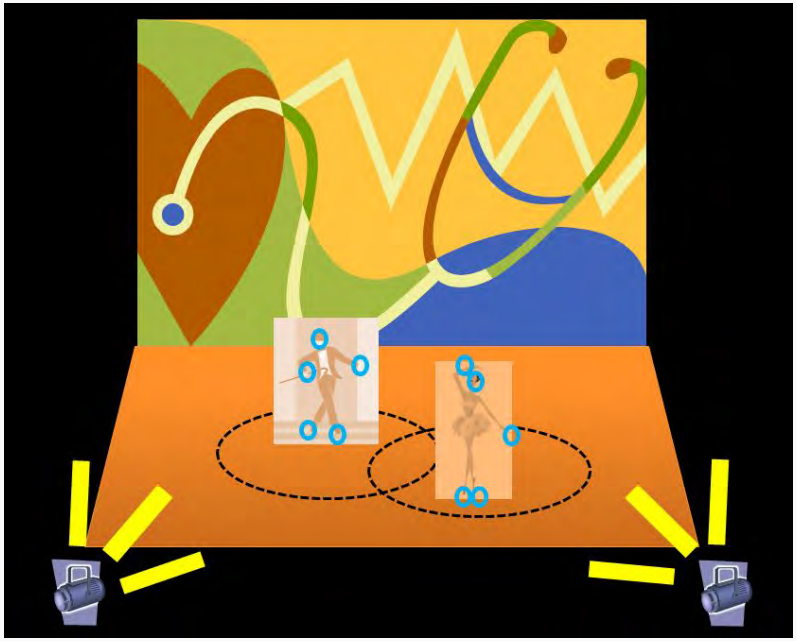
https://www.youtube.com/watch?v=_juVvaXFeOc
(1.49)

Introduction

- Motivating scenario



Two performers on the stage



When performers are near, the stage lights are turned on and the animations is projected

Prototype 1


Wearable Platform Demo
The background color changes based on the distance between each dancer and its colored cylinder

Introduction

- Challenges (platform)
  - Sensor data are transmitted across networks in real-time
  - The stage properties have to be properly managed
  - The virtual character reacts to the sensor data based on “rules” defined by the director via a GUI-based tool
- Solution
  - WISE (Wearable Item Service runtimE)
    - Harmoniously combines stereoscopic projected animations, wearable sensors, story, dancing, and music

Chun-Feng Liao, Wei-Chen Lu, Yi-Kai Hsiao, Wei-Chen Chang, Kung Chen and Zack Grannan, “WISE: a Wearable Platform for Performer-guided Mixed-reality Interactive Performance Art, ” in Proc. International Conference on Platform Technology and Service (PlatCon'16), 2016. (Best Paper Award)

Introduction

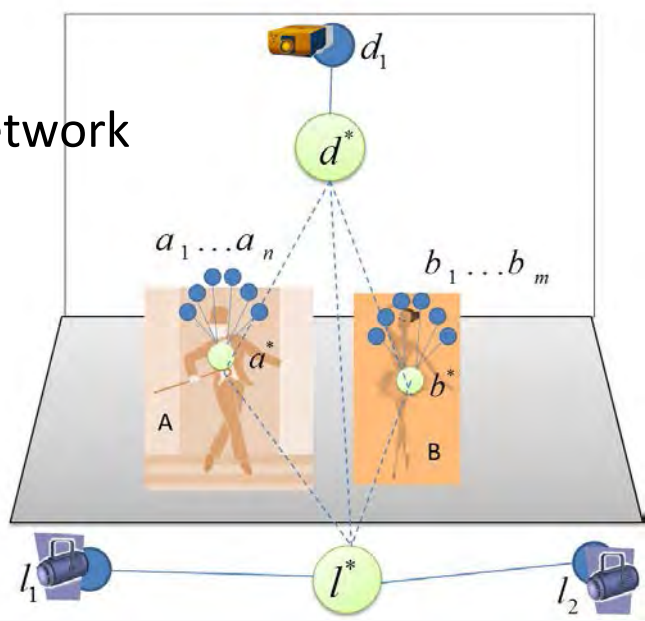
- Challenges (programming)
  - Directors should be able to implement their ideas quickly
  - Using traditional way to manage stage properties and domain logics simultaneously is tedious and error-prone.
- Solution
  - DIPS (Digital Interactive Performance Sketch)
    - Provides the common domain abstractions and their associated operations for interactive performance art.

Chun-Feng Liao, Zack Grannan, Ming-Chuan Lin, Kung Chen, Ru-Yi Lin, and Yi-Kai Hsiao, “A Functional Reactive DSL Service Facility for Mixed-Reality Interactive Performance Art,” in Proc. 9th IEEE International Conference on Service-Oriented Computing & Applications (IEEE SOCA 2016), 2016.

Introduction

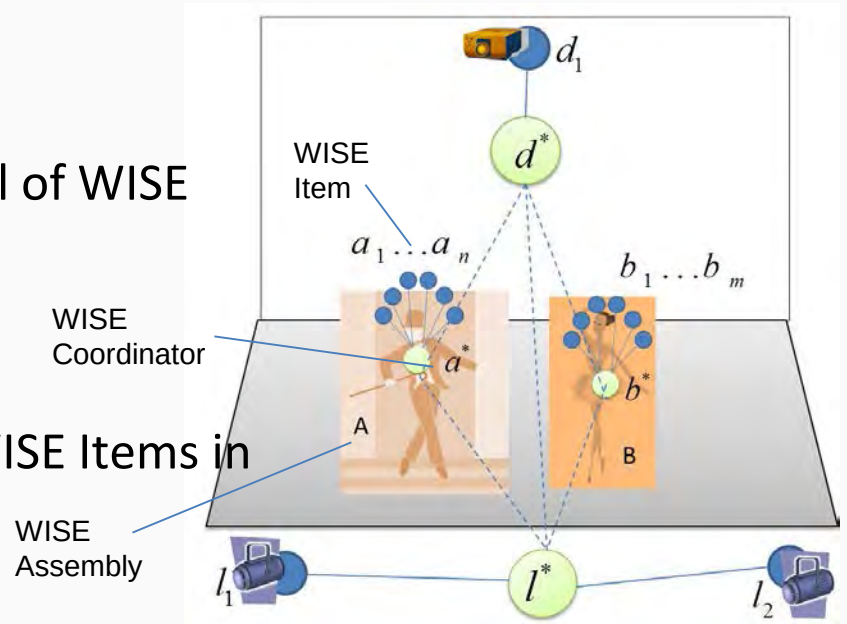
- System model
  - WISE Item ($a_1 \ldots a_n, b_1 \ldots b_m$)
    - Wearable devices such as mo-cap or remote controllable LED array
  - WISE Coordinator a^*, b^*
    - Protocol gateways between BAN and IP network
  - WISE Assembly $\alpha = (c^\alpha, I^\alpha) \in C \times 2^I$
    - One coordinator plus a set of items
    - Ex: A is a WISE Assembly where

$$A = (a^*, [a_1 \ldots a_n])$$



Introduction

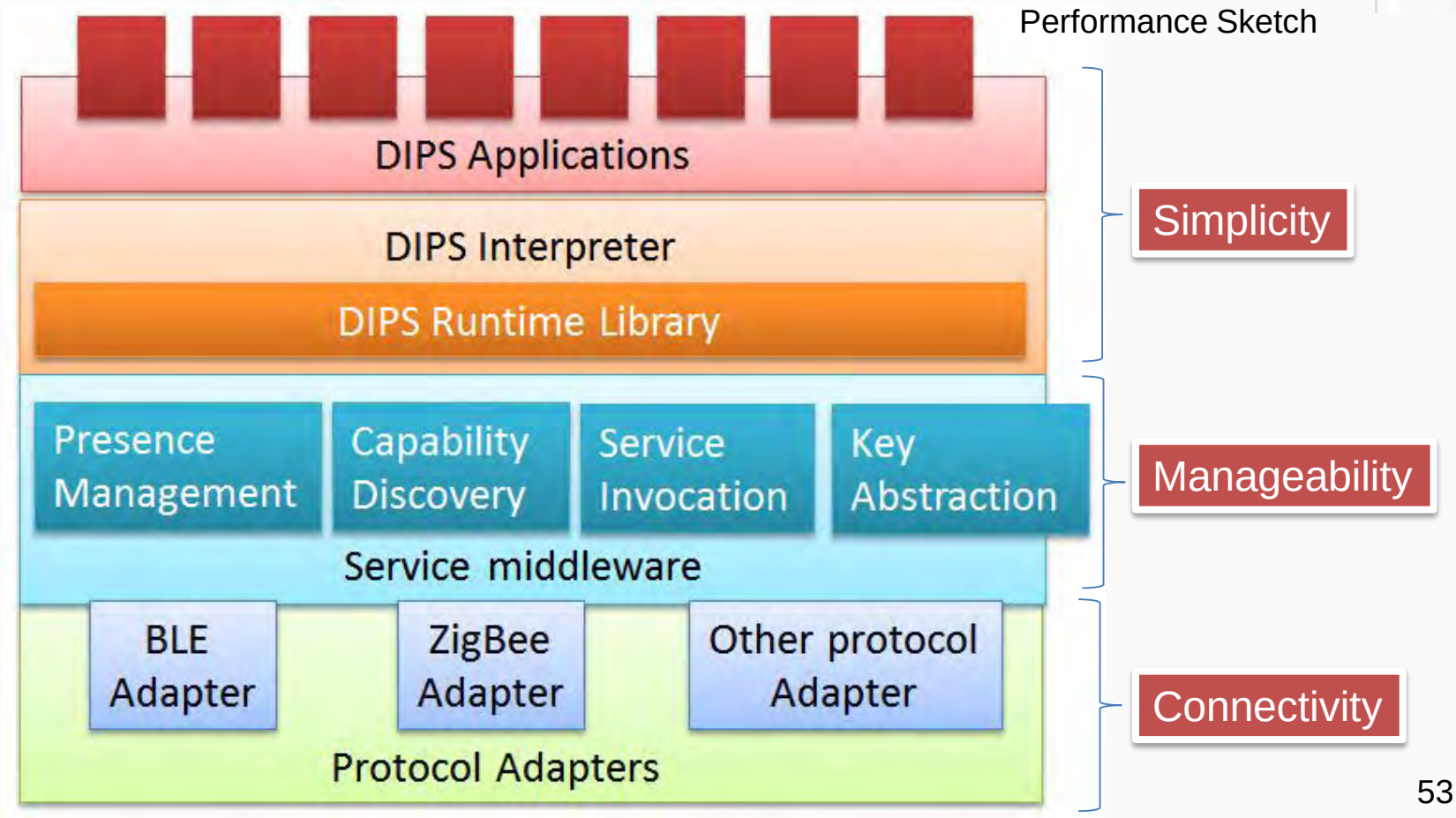
- Technical issues
  - Connectivity
    - Intra- and inter- WISE Assembly communications
  - Manageability
    - Presence management and control of WISE Items and WISE Coordinators
  - Simplicity
    - Define the reactive rules among WISE Items in an intuitive way



Approach

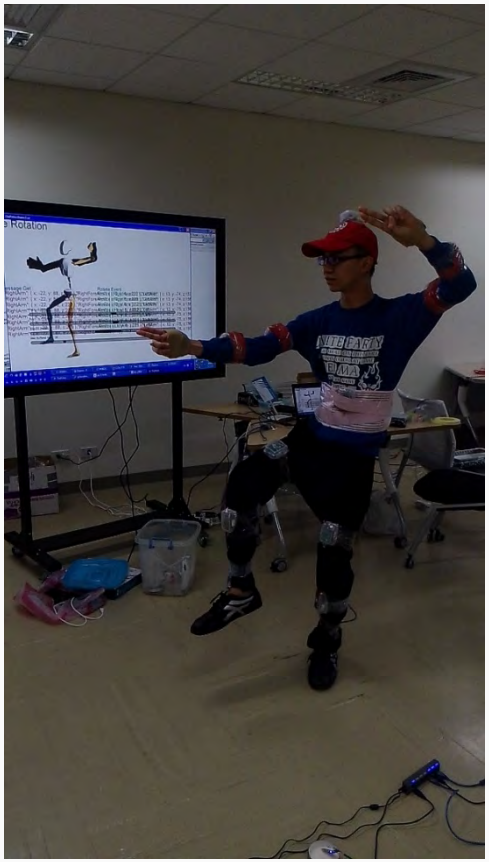
- Big picture

DIPS=Digital Interactive Performance Sketch

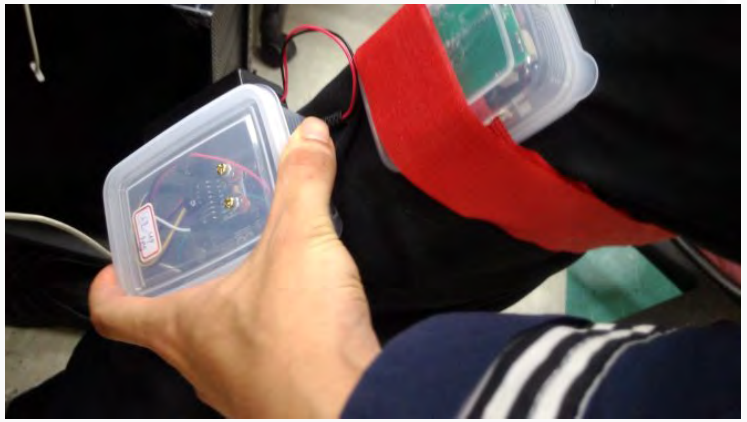


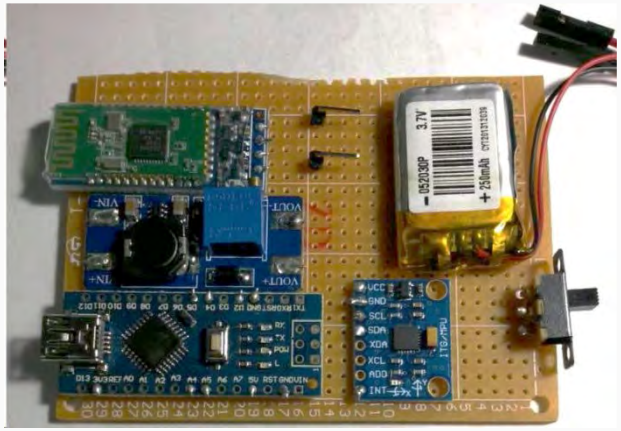
WISE Item (v1)

version 1



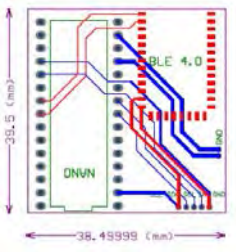
version 2

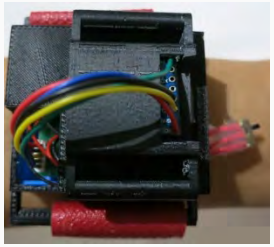


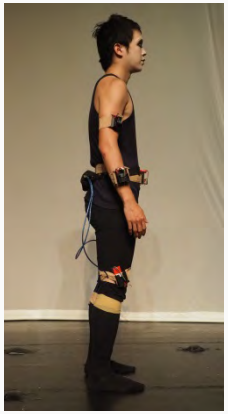


WISE Item (v2)

- WISE Item
  - Composed of ATMEGA328P, MPU-6050 posture sensor, a CC2540 BLE chip and a 3.7 V lithium cell
  - The covering wearable plastic case is design by our team and made with a 3D printer
  - The performer wears 14 WISE Items in live performance

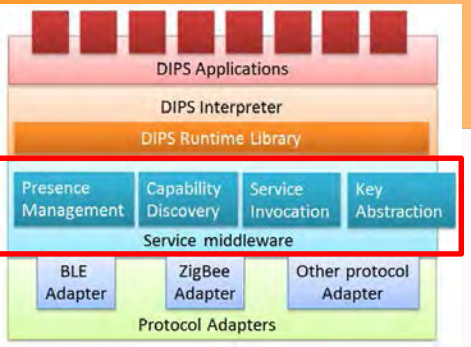






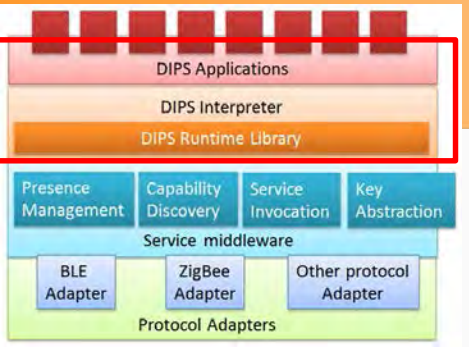
WISE Item (v3)

- 硬體體積縮小化，輕便易穿戴
- 彈性穿戴設計，不分年齡性別皆適用



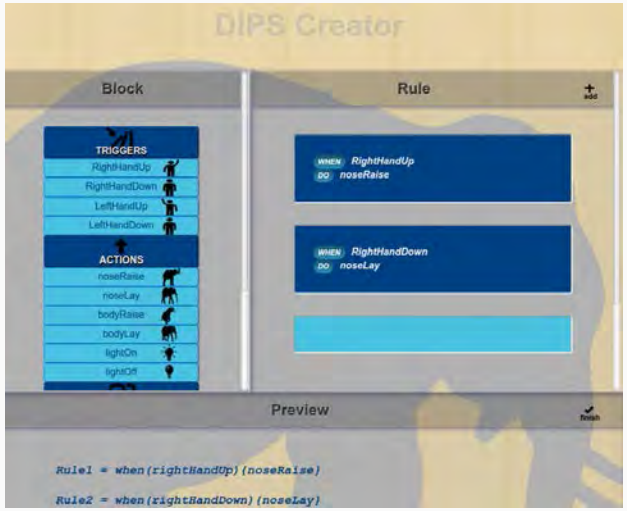
Approach

- Service middleware
  - Broking and routing messages
    - Publish-subscribe exchanging style
    - Routing messages based on message headers
  - Presence and capability management
    - Finding WISE Items : getting remote references of WISE Items that meets search criteria
    - Diagnosing WISE Items: monitoring the status of devices



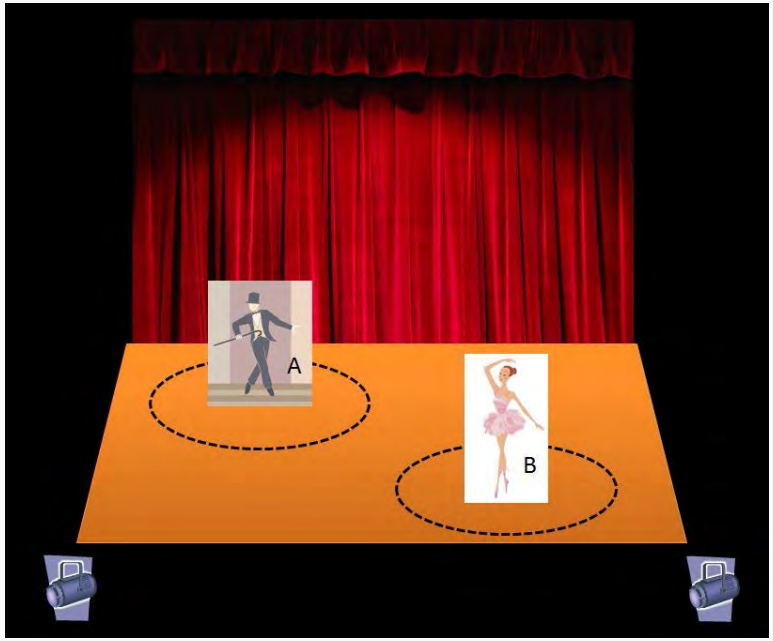
Approach

- Programming support
  - DIPS (Digital Interactive Performance Sketch)
    - An Internal DSL (Domain Specific Language) hosted by Scala
    - Realize TAP (Tigger-Action Programming) model for interactive performance art
  - DIPS Creator
    - Web-based drag-and-drop style end-user programming interface
  - DIPS Interpreter
    - Execute DIPS on the fly

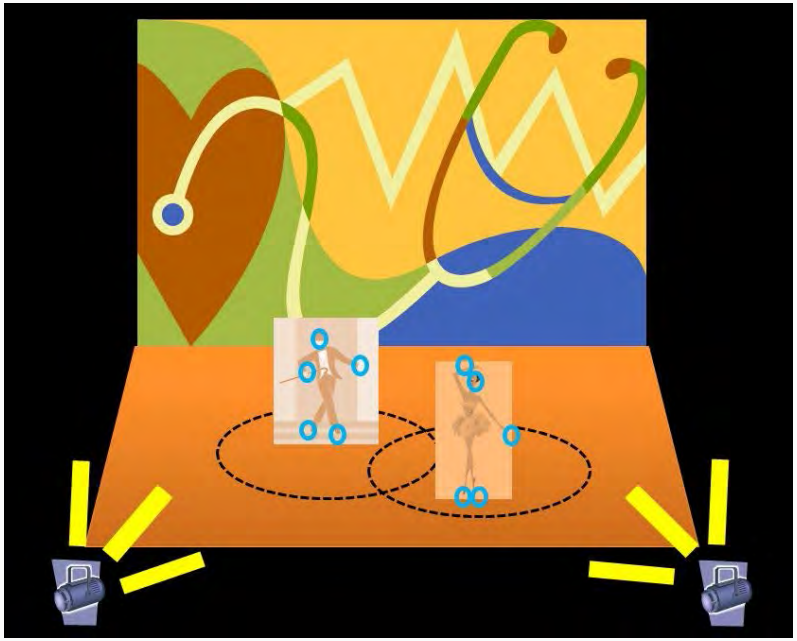


Example

- Motivating scenario



Two dancers on the stage



When dancers are near, we want the stage lights to be turned on and the animations to be projected

Example

- Implementing the motivating scenario.

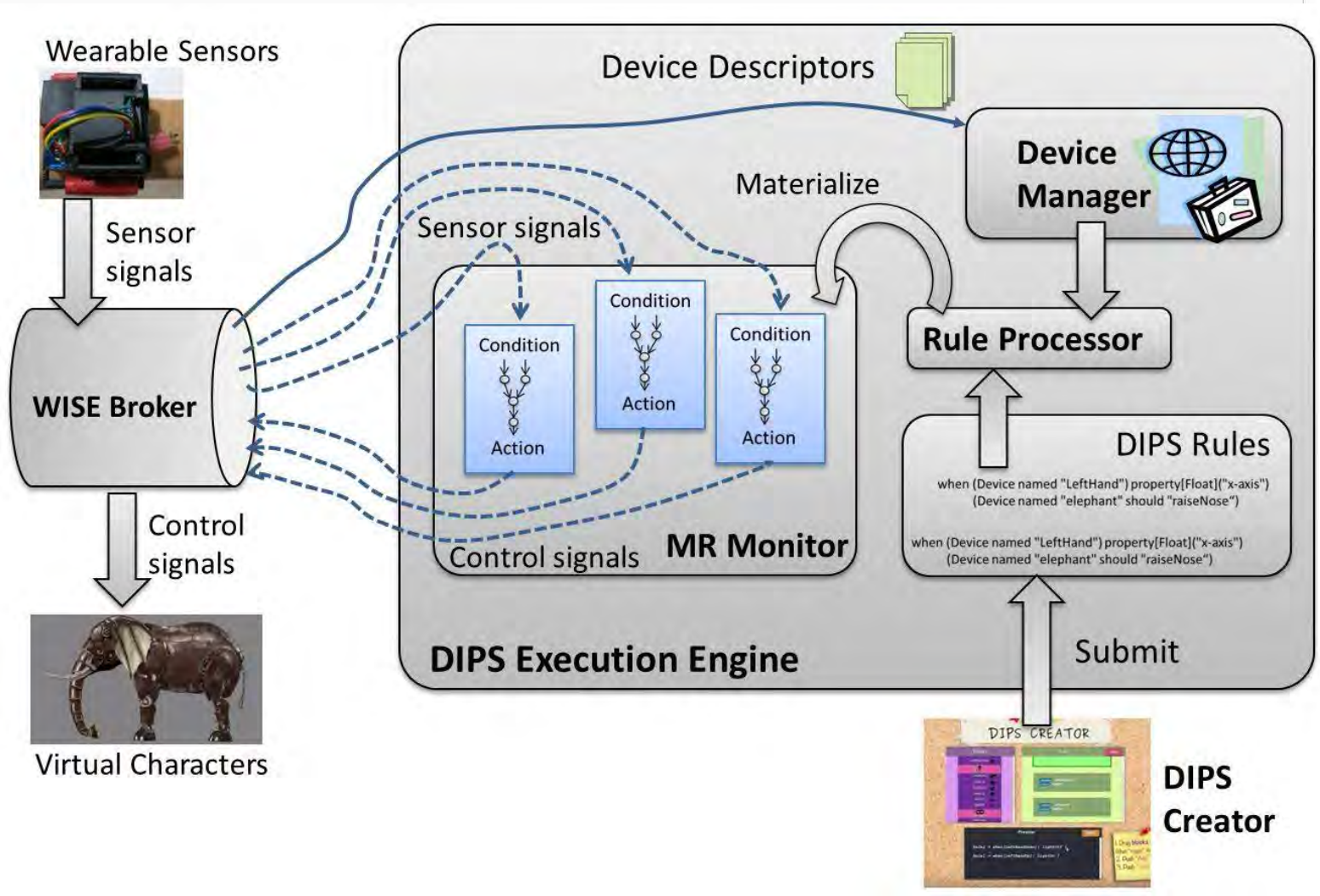
```
new Thread(() -> {
    for(;;){
     float distance =
         distanceOf(in(dA.pos),in(dB.pos));
     while(distance > 100) wait(1);
       out(SPOTLIGHT,ON);
       out(PROJECTOR,ON);
     while(distance <= 100) wait(1);
       out(SPOTLIGHT,OFF);
       out(PROJECTOR,OFF);
}}).start();
```

Example

- motivating scenario reimplemented using DIPS

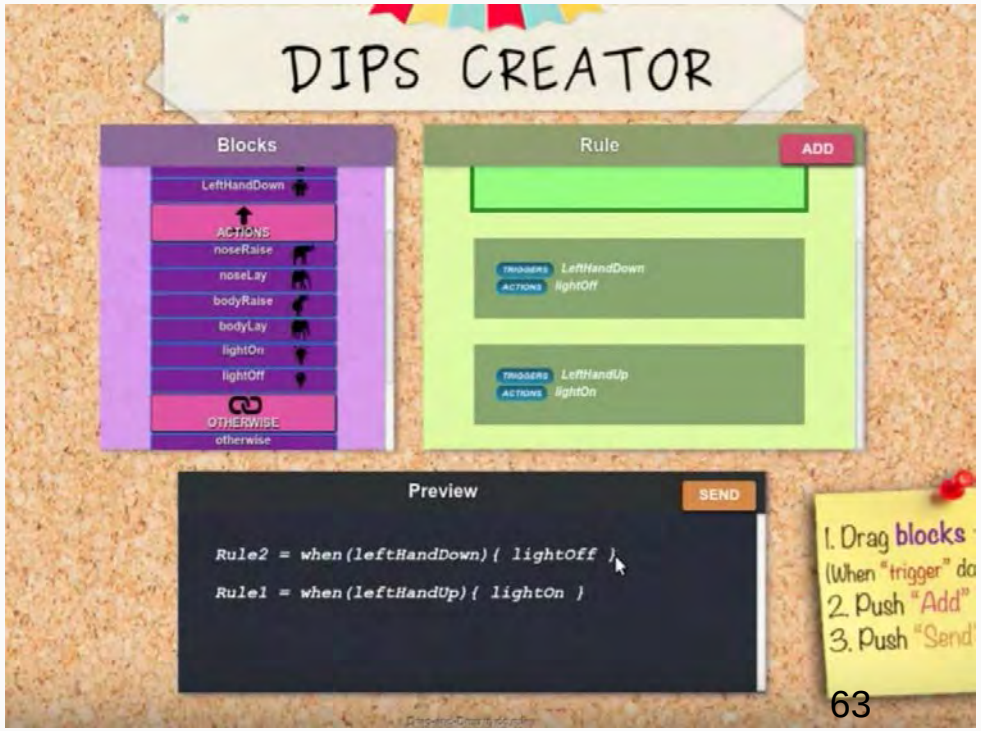
```
val distance = (dancerA.pos zip dancerB.pos)
    map toDistance
when (distance < 100) {
    SPOTLIGHT should ON, PROJECTOR should ON
}
when (distance >= 100) {
    SPOTLIGHT should OFF, PROJECTOR should OFF
}
```

Approach

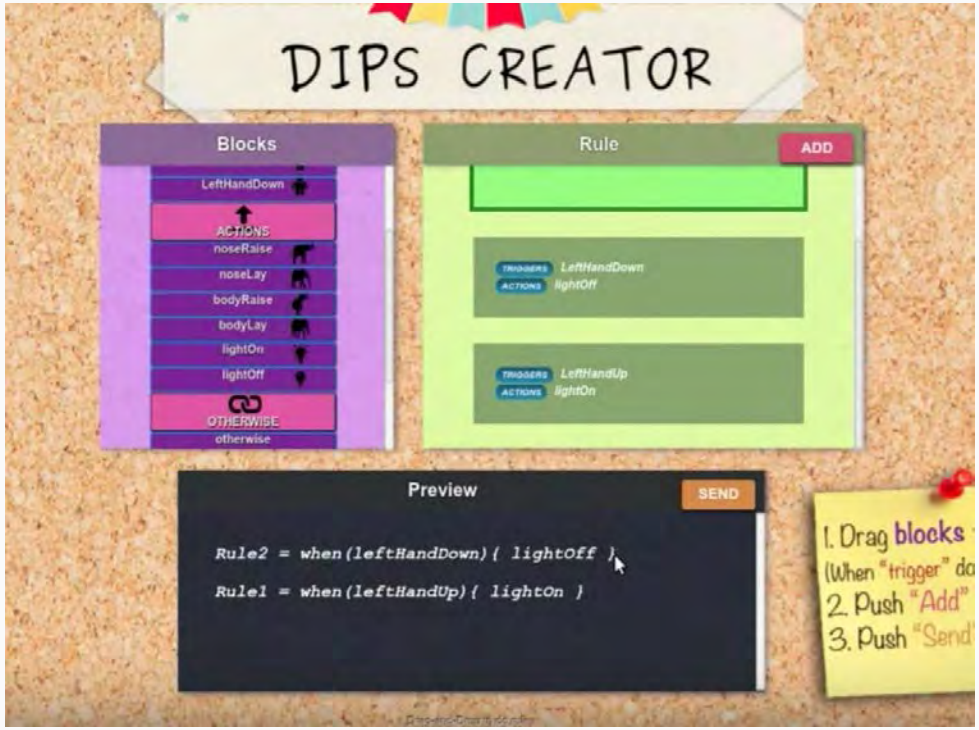

Wearable Sensors
Sensor signals
WISE Broker
Control signals
Virtual Characters
Device Descriptors
Device Manager
Materialize
Sensor signals
Condition
Action
Condition
Action
Condition
Action
Control signals
MR Monitor
Rule Processor
DIPS Rules
when (Device named "LeftHand") property[Float]("x-axis")
(Device named "elephant" should "raiseNose")
when (Device named "LeftHand") property[Float]("x-axis")
(Device named "elephant" should "raiseNose")
DIPS Execution Engine
Submit
DIPS CREATOR
DIPS Creator

Implementation

- Programming support
  - DIPS creator
    - Web-based drag-and-drop style end-user programming interface
    - Execute DIPS on the fly

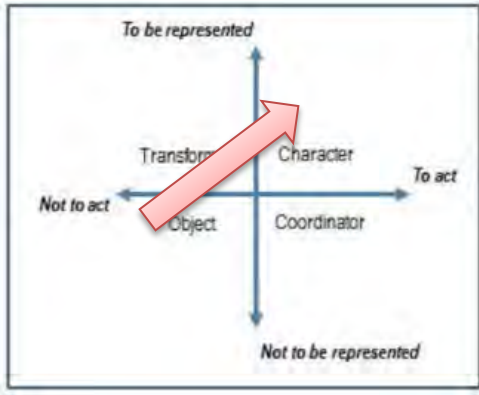


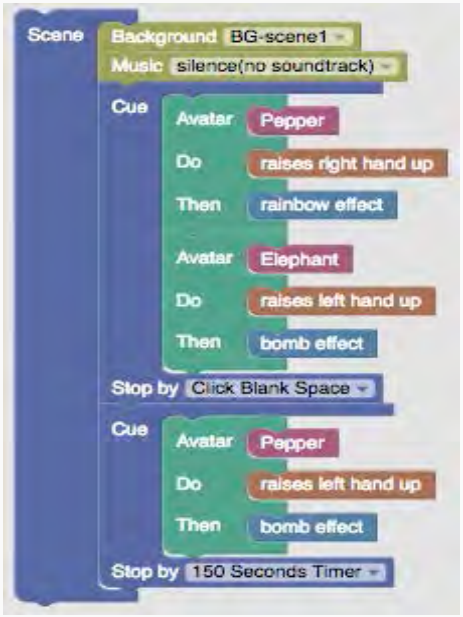
DIPS v1


DIPS CREATOR
Blocks
LeftHandDown
ACTIONS
noseRaise
noseLay
bodyRaise
bodyLay
lightOn
lightOff
OTHERWISE
otherwise
Rule
ADD
TRIGGERS LeftHandDown
ACTIONS lightOff
TRIGGERS LeftHandUp
ACTIONS lightOn
Preview
SEND
Rule2 = when(leftHandDown){ lightOff }
Rule1 = when(leftHandUp){ lightOn }
1. Drag blocks
2. Push "Add"
3. Push "Send"

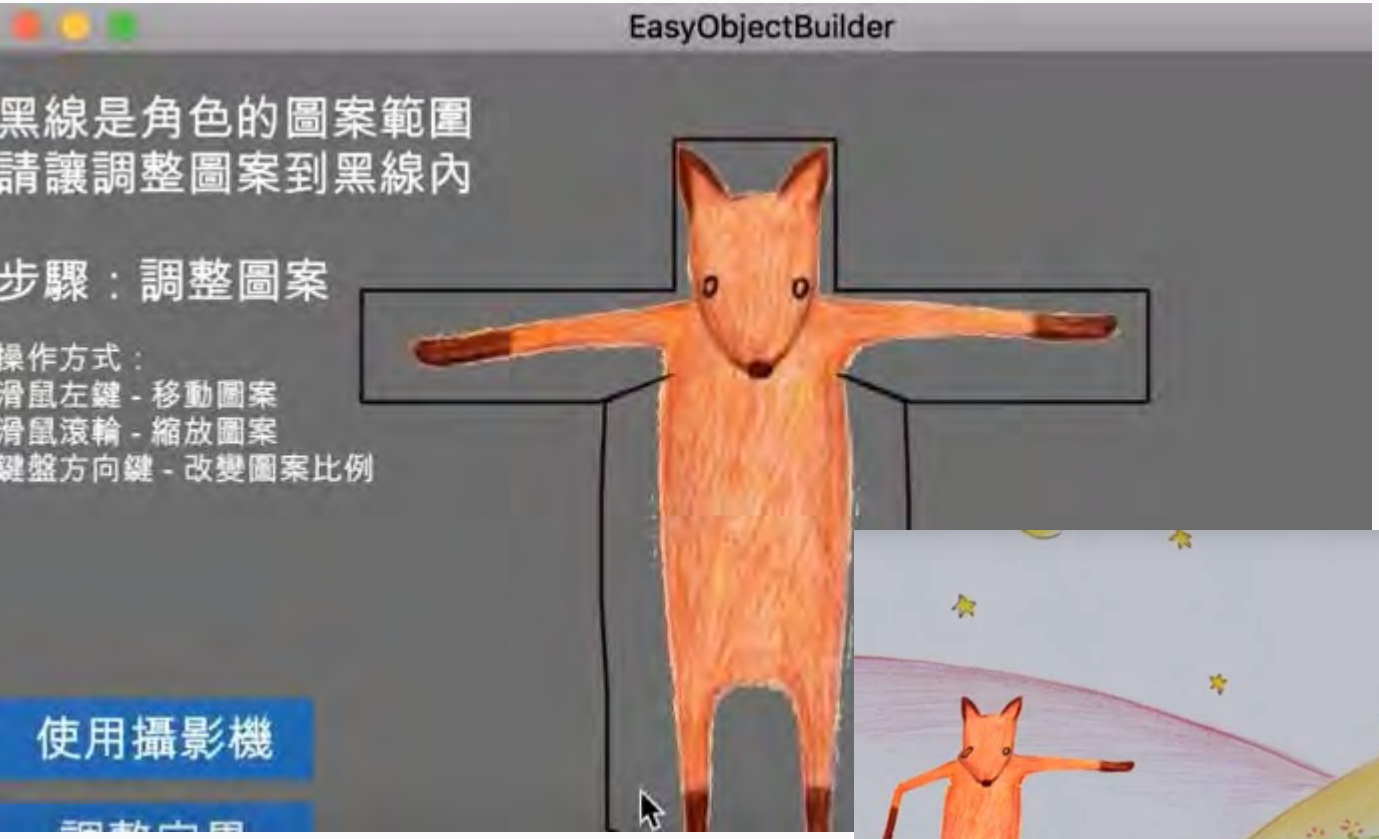
DIPS v2


Block Library
Save "avator_pepper"
Delete "avator_pepper"
Input
Field
Colour
Character
StageEffect
Background
name avator_pepper
inputs
dummy input
fields left
pepper:
position(x= 0 , y= 0 , z= 0)
sub_topic_name= mocap-data-01
text Pepper
automatic inputs
↑ top connection
colour
hue: 330°
Block Creating:
Pepper


To be represented
Transform
Character
To act
Not to act
Object
Coordinator
Not to be represented

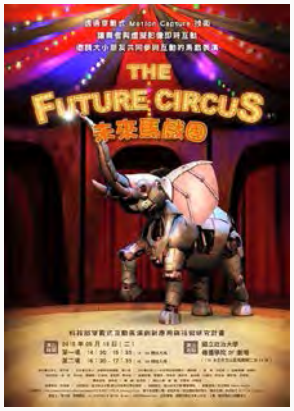

Scene
Background BG-scene1
Music silence(no soundtrack)
Cue
Avatar Pepper
Do raises right hand up
Then rainbow effect
Avatar Elephant
Do raises left hand up
Then bomb effect
Stop by Click Blank Space
Cue
Avatar Pepper
Do raises left hand up
Then bomb effect
Stop by 150 Seconds Timer

DIPS v3


EasyObjectBuilder
黑線是角色的圖案範圍
請讓調整圖案到黑線內
步驟：調整圖案
操作方式：
滑鼠左鍵 - 移動圖案
滑鼠滾輪 - 縮放圖案
鍵盤方向鍵 - 改變圖案比例
使用攝影機

Cases and Applications

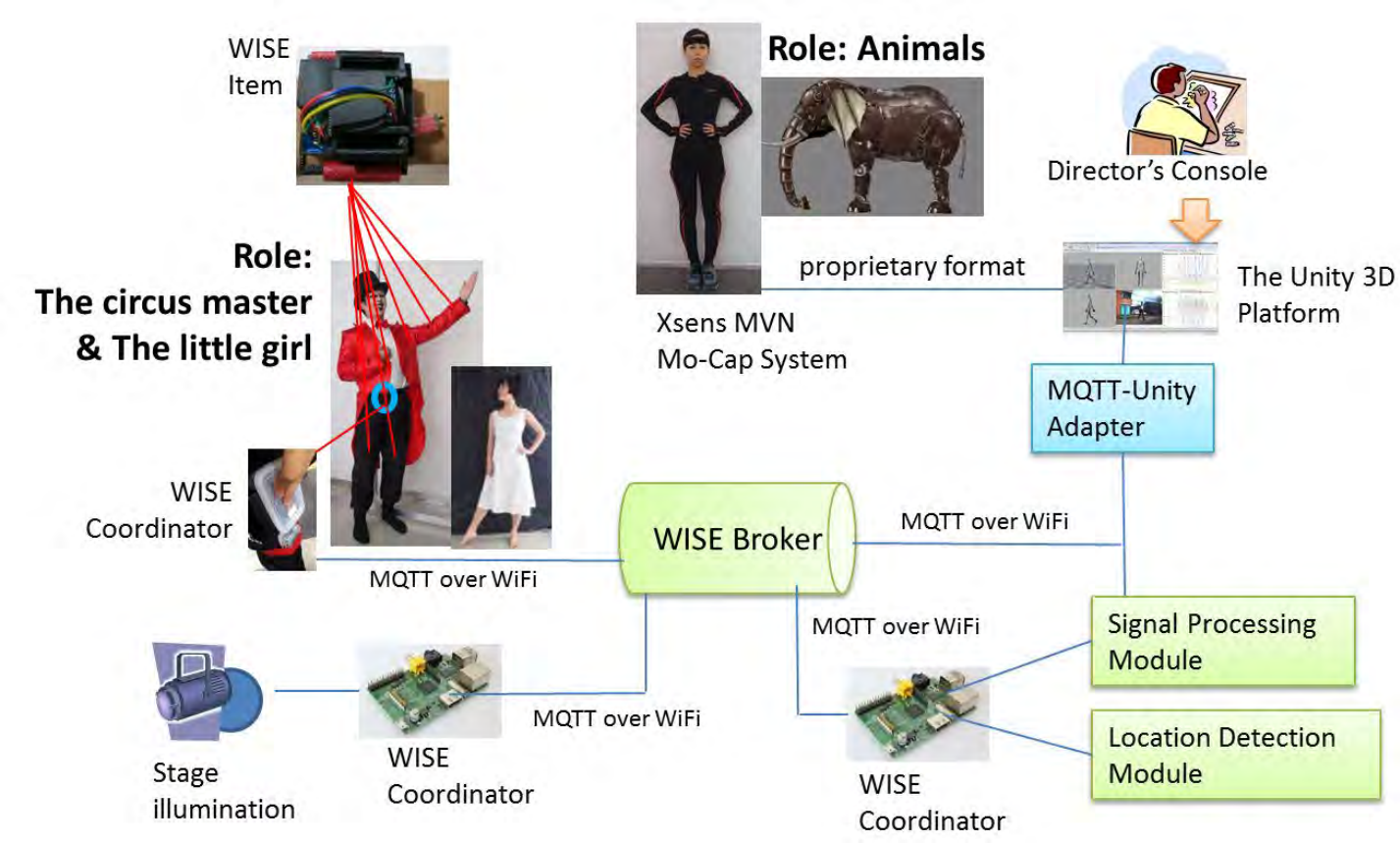
- Future Circus
  - A proof of concept performance realized based on WISE
  - Publicly performed or demonstrated in Kaohsiung Exhibition Center, Digital Art Festival Taipei'15, and ACM UbiComp/ISWC Design Exhibition '15



Hsin Huang, Hsin-Chien Huang, Chun-Feng Liao, Ying-Chun Li, Tzu-Chieh Tsai, Li-jia Teng, and Shih Wei Wang, "Future Circus: A Performer-Guided Mixed-reality Performance Art, " in Adjunct Proc. International Symposium on Wearable Computers (ISWC), Design Exhibition track, Osaka, Japan, 2015.

Future Circus

- System architecture



Cases and Applications

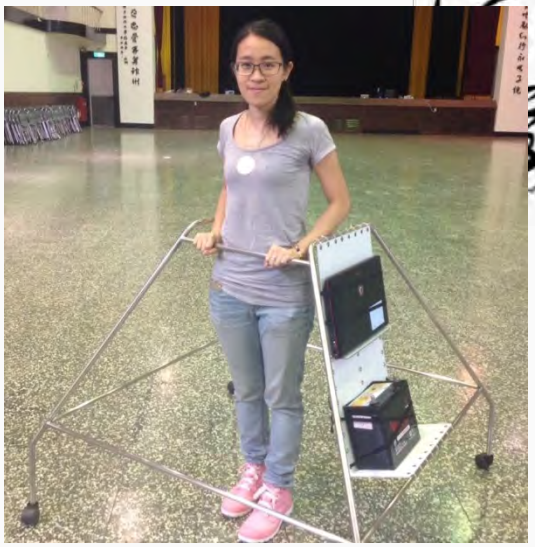
Step In and Out of the Dreams

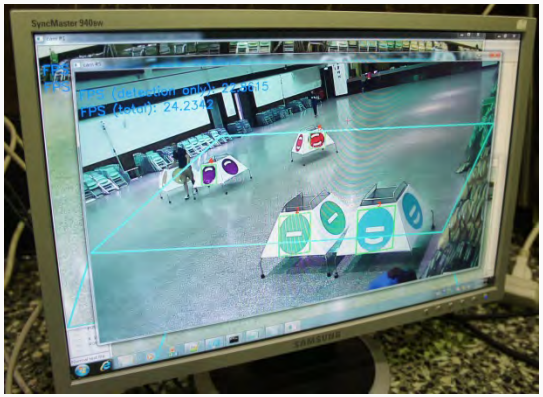
Ya-Lun Tao, Chun-Feng Liao, Hsuan Huang, Ya-Wen Su, Yo-Ja Lin, Pin-Hsin Chen, Tzu-Chieh Tsai, “Step In and Out of the Dreams: Toward an Immersive and Interactive Virtual Experience of Dreams, ” in Adjunct Proc. International Symposium on Wearable Computers (ISWC), Design Exhibition track, Heidelberg, Germany, 2016.

2015/10/17~10/22
Songshan Cultural and Creative Park
松山文創園區1號倉庫

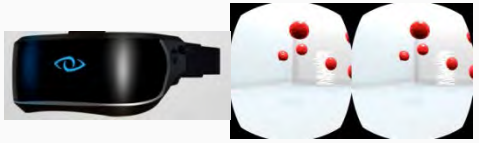
Dreaming Device Design

- Supporting car
  - Laptop and batteries
- Wearable devices
  - VR glasses
  - WISE Items
- Global positioning
  - Camera
  - Label





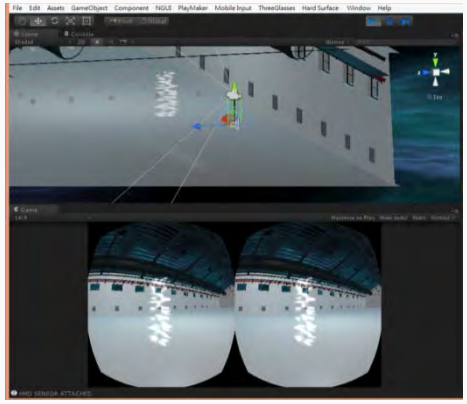
Implementation: Step in and out of the Dream



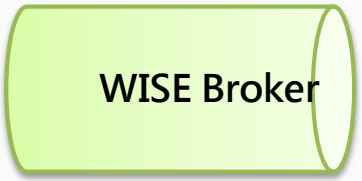
Rendering
- Rendering results to the VR glasses

VR glasses

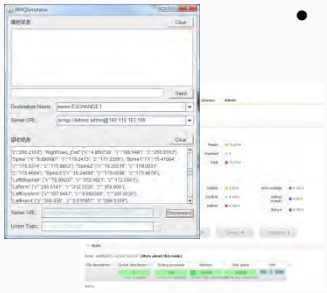
Global positioning
- Camera-based
- Also calculate relative positions



Mo-cap
- Sense motions
- One-click calibration
- 30 FPS



WISE
- Monitoring and broking messages



Virtual world (Unity)
- Multi-user navigation
- Reactions and effects control

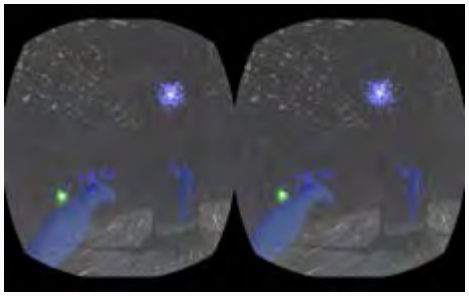
Cases and Applications: Electronic Skin

2016/5/7~5/15
Museum of Contemporary Art, Taipei
台北當代藝術館

Electronic Skin

Global positioning

- Camera-based
- Also calculate relative positions



Rendering

- Rendering results to the VR glasses
- Also renders motions of hands

VR glasses

感測器

Mo-cap

- Sense motions
- One-click calibration
- 60 FPS

WISE Platform

WISE

- Monitoring and broking messages

Virtual world (Unity)

- Multi-user navigation
- Reactions and effects control

Conclusion

- Platform and programming support for interactive performance art
  - Impromptu performance: virtual characters are able to react to real performers' actions
  - Managed performance: addresses connectivity, and context-awareness issues
  - Abstracted performance: focus on high level performance flow, making direction of a performance simpler
- Future work
  - Enable distributed interactive performances
  - Improve the robustness of WISE Items

Q & A