



## STEAM Education Enriching Knowledge Series: Sharing session on Market Trend and Career Pathways of the Wearable Technology Industry (New)

The Hong Kong Productivity Council (HKPC)

23 Aug 2023, 2pm – 4pm



# Introduction to the latest market trend in the wearable technology industry

## Case Study:

Wearable technology on body motion analysis and Elderly Fall Prevention System (with demonstration)

## Speaker:

Mr. Gordon Lee

VP, Business Development

**Booguu Company Limited**

[www.booguu.bio](http://www.booguu.bio)





# BOOGUU COMPANY LIMITED



Wearable Healthcare Platform





# OUR MISSION

Reduce Elderly Falls  
&  
Improve Therapy Outcome







# PROBLEM: ELDERLY PHYSICAL DECLINE & FALLS

## 1 Falls are a leading cause of injury among older adults

- 30% of 65 years and older suffer from falls each year
- 75% of falls results in fractures and head trauma

## 2 Age related declines in balance, strength, and mobility

- 25% loss of muscle mass between ages 30 to 70
- Balance declines starting in the 40s

## 3 Existing prevention and assessment tools are insufficient

- Primary care based screenings have limited accuracy
- Instrumented assessment are expensive, long, with limited access

Multiply by Growing  
Worldwide Ageing Trend

Aged 65+ (2021)

**HK: 1.4 Million**  
**China: 176 Million**

**Japan: 36 Million**  
**USA: 56 Million**

**Accelerated  
by Covid Isolation**

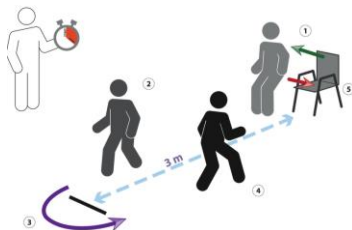


# Prevention - Traditional Assessment Methods

## 1. 問卷

## 2. 動作測試

- Timed Up and Go (TUG)
- Berg Balance Scale (BBS)
- Sit-to-Stand(STS)



計時，記錄，觀察  
針對高風險群組

## 3. 器材測試 (黃金標準)

- Biodex
- 測力板 Bertec® Force Plate
- 電子走道 GaitRite
- 視頻分析



準確但昂貴  
需要特殊培訓





## Beyond Eyes can see

### Gait Variability and Fall Risk in Community-Living Older Adults: A 1-Year Prospective Study

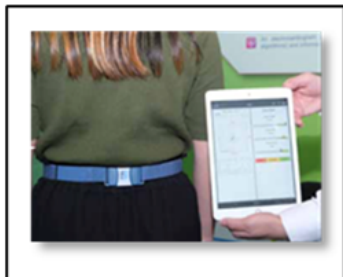
Jeffrey M. Hausdorff, PhD, Dean A. Rios, BS, Helen K. Edelberg, MD

步伐變異係數  
Gait Variability

“Stride time variability was  $106 \pm 30\text{ms}$  in subjects who subsequently fell”

“Logistic regression also showed that stride time variability predicted falls ( $p < .05$ )”

步固產品就是針對這方面的需求研發製成。



輕便裝置

快速測試

綜合因素

雲端計算

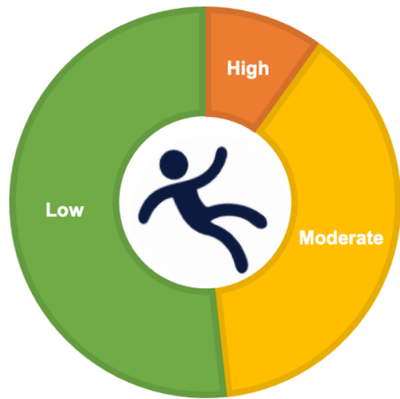
智能評估

能夠測出不同程度的跌倒風險



# SOLUTION:

## FALL RISK STRATIFICATION & THERAPY MONITORING



- 1
  - Identify at-risk individuals using wearable sensor – quickly and accurately
  - Provide therapy based on risk levels and risk factors
  - In community, outpatient, and inpatient settings – everywhere

- 2 Monitor and track patients progress using mobile app and wearable sensor



Tandem Standing

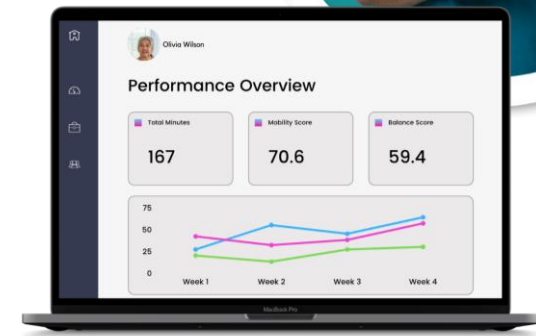


Single Leg Lift



Single Leg Side Lift

Balance, Mobility, and Strength Data



Enable therapists to better identify and treat at risk patients using accurate data and actionable insights.





# Award winning wearable healthcare platform to reduce risk of falls and improve therapy outcome with objective body movement analysis

aspire™



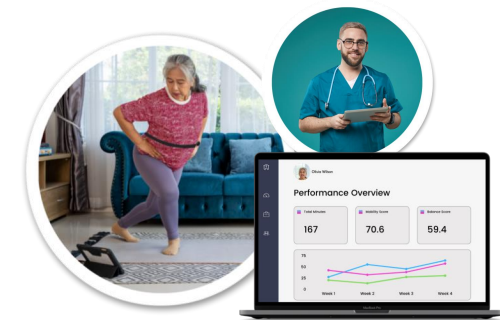
Inpatient & Outpatient  
Fall Risk Prevention and Management

ASPIRE BALANCE™



Balance Rehabilitation Training

Aspire Motion Connect™



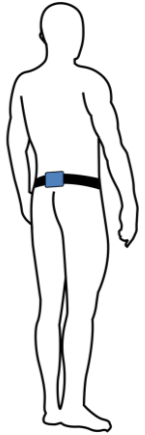
Remote Therapy Monitoring

- **AI and Machine Learning**
- **Wearables & Digital Health**



# INNOVATION: PATENTED BODY MOTION ANALYSIS

Greater accessibility to clinical grade metrics



Single Sensor

Multiple Analysis



**Machine Learning**  
Artificial Recurrent  
Neural Network

**Balance**

**Strength**

**Gait & Mobility**

## Balance & Postural Sway

- Sway Length & Area
- Romberg Ratio
- Smoothness

## Sit to Stand Transitions

- Movement Power and Force
- Stability and Control
- Unsafe Movement Patterns

## Walking Gait

- Cadence
- Velocity
- Single Support & Double Support
- Variability and Stability
- Symmetry
- Ground Reaction Force
- Power and Energy

## KEY BENEFIT

**Data Driven Risk Analysis  
At Scale & Cost Effective**

**Secured Cloud Platform**  
Data Integration API  
Data in Singapore

## Gold Standard Validated

- GAITRite® Electronic Walkway Mat
- Bertec® Force Plate
- Noraxon® myoMotion™ IMU



- 平衡和步態問題
- 肌肉無力
- 關節僵硬和疼痛
- 體感變化和喪失
- 視力
- 藥物副作用
- 血壓
- 飲食 - 低血糖、脫水、酒精等
- 慢性疾病 - 關節炎、糖尿病、中風等
- 心理因素 - 跌倒恐懼

## 綜合因素

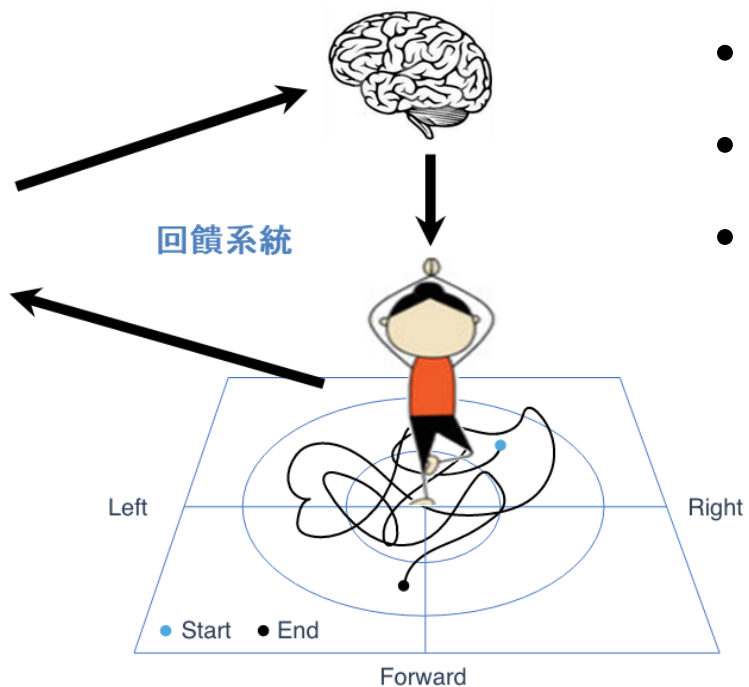
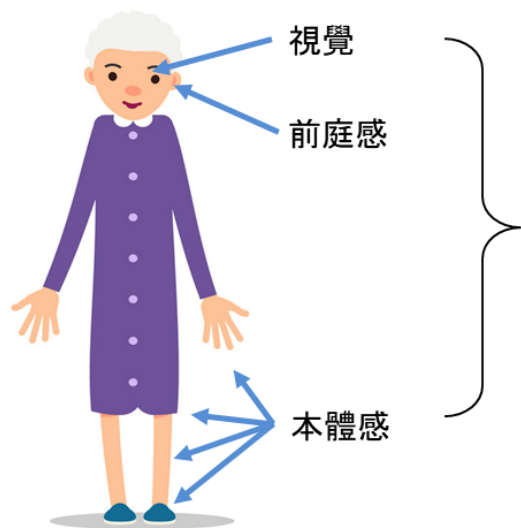
風險因素反映在  
日常動作之中





# 靜態平衡

保持站姿穩定能力



- 感應器官功能
- 大腦訊息處理
- 訊息傳遞功能
- 神經肌肉控制

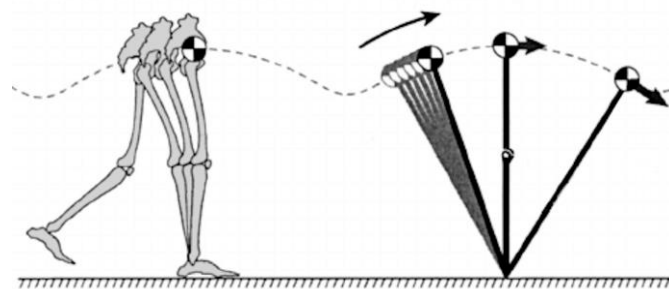




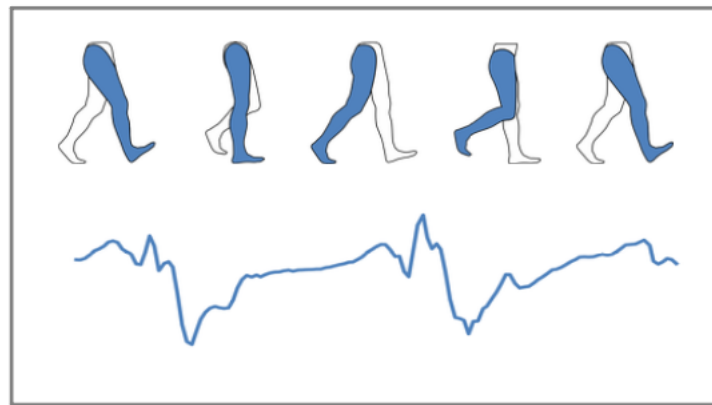
## 步態風險因素

下半身力量 步速穩定性  
左右對稱性 動作協調性

- 每步能量
- 上下運動幅度
- 髖/骨盆穩定
- 每步變化量
- 步頻
- 時間
- 著陸力
- 對稱性



前進加速度





## 五次坐到站測試

下肢功能 下肢力量  
協調性 功能性

- 完成次數和時間
- 站起力量
- 功能性效率
- 是否可以控制緩降





# Fast - Accurate

## 一個傳感器



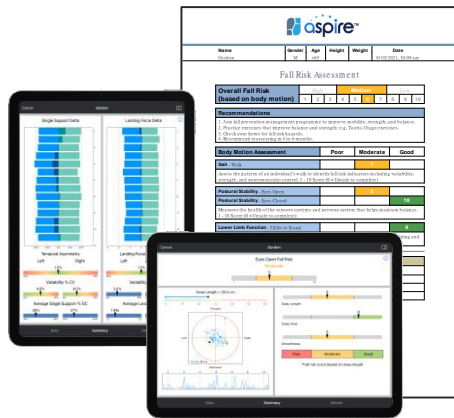
- 隨時隨地
- 簡單快速
- 準確客觀

## 三項簡單測試



- 行走步態
- 靜態平衡：睜眼和閉眼
- 下肢功能

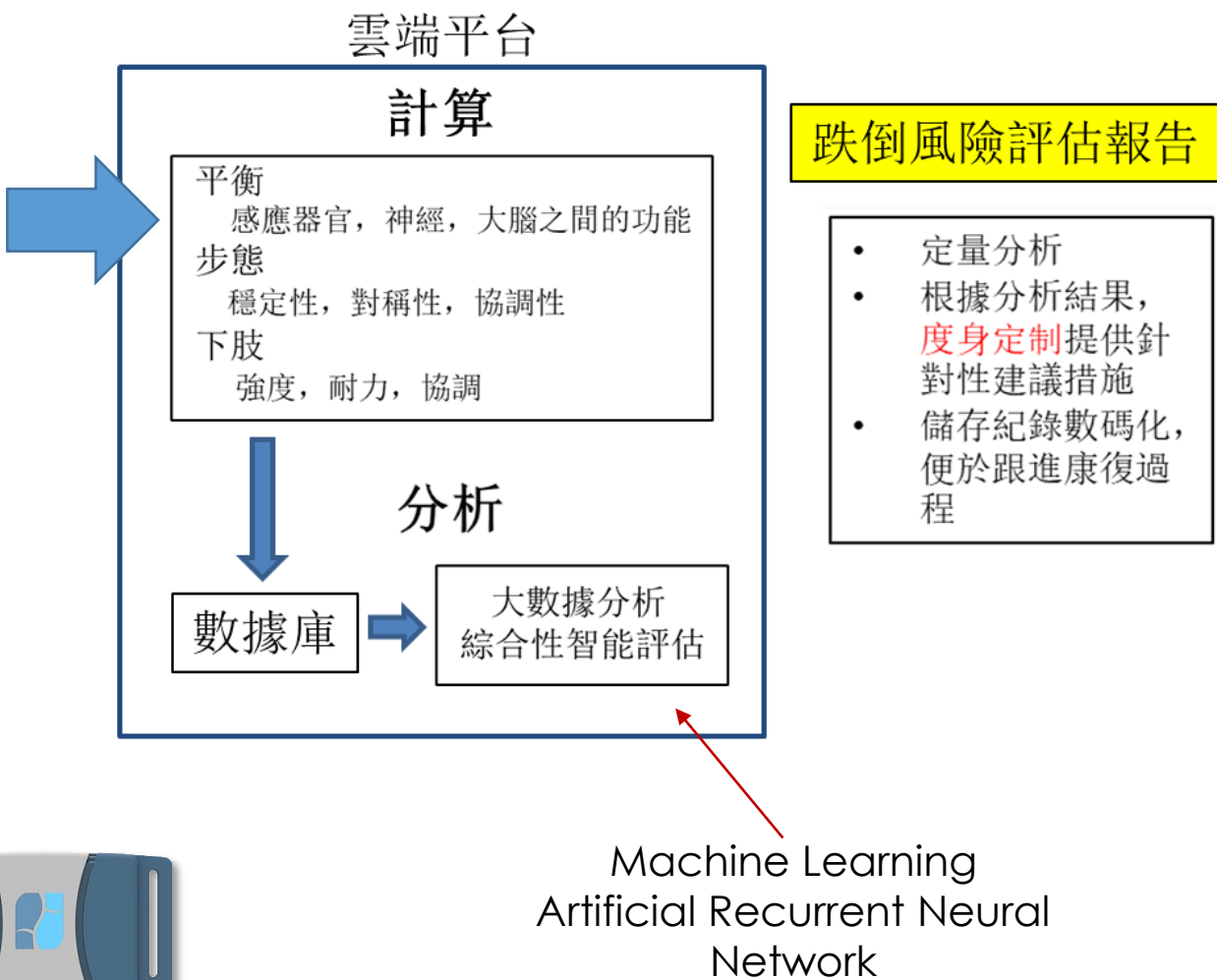
## 五分鐘



- 綜合報告
- 度身定制建議
- 跟進康復進程



## Exam & Data flow







# Personalized Assessment Report



名字	性別	年齡	身高	體重	日期
Gordon	男	<65			8/10/2021 上午10:08

跌倒風險評估

整體跌倒風險 (基於身體動作)	高	中	低
	1 2 3 4 5 6 7 8 9 10		

建議

1. 參加防跌管理班去改善活動能力，下肢力量與平衡能力。  
2. 練習有助提升力量及平衡力的運動，例如太極。  
3. 留意家居可能引致跌倒的原因。  
4. 建議大約4-6個月重新評估。

身體動作評估	較差	適中	良好
步態—行走		7	
評估個人行走的方式，以識別跌倒風險指標，包括變化性、力量和神經肌肉控制。分數：1-10分 (0 = 不能安全完成)			
靜態控制—睜眼		5	
靜態控制—閉眼			10
測量有助於維持平衡的感覺系統和神經系統的健康狀況。分數：1-10分 (0 = 不能安全完成)			
下肢功能—5次坐到站			9
評估下肢的功能性，以支持從坐姿到站姿以及回到坐姿的運動。分數：1-10分 (0 = 不能安全完成)			

自述身體健康狀況

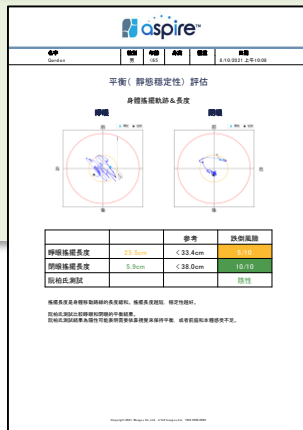
過去六個月是否跌倒	否
快速起身時是否感到眩暈	
室內燈光下視力情況	
每日服用處方藥物的數量	

## 針對個人跌倒風險因素的預防建議

### 建議

1. 參加防跌管理班去改善活動能力，下肢力量與平衡能力。
2. 練習有助提升力量及平衡力的運動，例如太極。
3. 留意家居可能引致跌倒的原因。
4. 建議大約4-6個月重新評估。

## 詳細的深入分析





名字	性別	年齡	身高	體重	日期
V	女	<65	165 cm	58 kg	9/7/2021 下午5:23

## 跌倒風險評估

整體跌倒風險 (基於身體動作)	高			中				低		
	1	2	3	4	5	6	7	8	9	10

### 建議

1. 睜眼時的平衡比閉眼時的平衡好得多。請向醫生諮詢您的神經感覺功能。
2. 向您的醫生諮詢藥物的使用及其副作用。
3. 參加防跌管理班去改善活動能力，下肢力量與平衡能力。
4. 處理視力，姿勢性低血壓及足部問題。
5. 建議透過家居評估改善家居安全。

身體動作評估	較差	適中	良好
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步態—行走			9
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評估個人行走的方式，以識別跌倒風險指標，包括變化性、力量和神經肌肉控制。分數：1 - 10分 (0 = 不能安全完成)

靜態控制—睜眼			8
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靜態控制—閉眼	1		
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測量有助於維持平衡的感覺系統和神經系統的健康狀況。分數：1 - 10分 (0 = 不能安全完成)

下肢功能—5次坐到站			9
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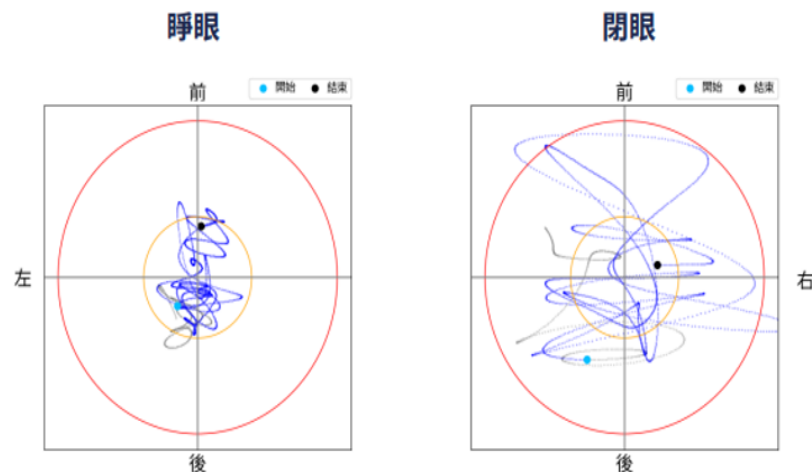
### 自述身體健康狀況

過去六個月是否跌倒	否
快速起身時是否感到眩暈	否
室內燈光下視力情況	良好
每日服用處方類藥物的數量	

名字	性別	年齡	身高	體重	日期
V	女	<65	165 cm	58 kg	9/7/2021 下午5:23

## 平衡（靜態穩定性）評估

### 身體搖擺軌跡 & 長度

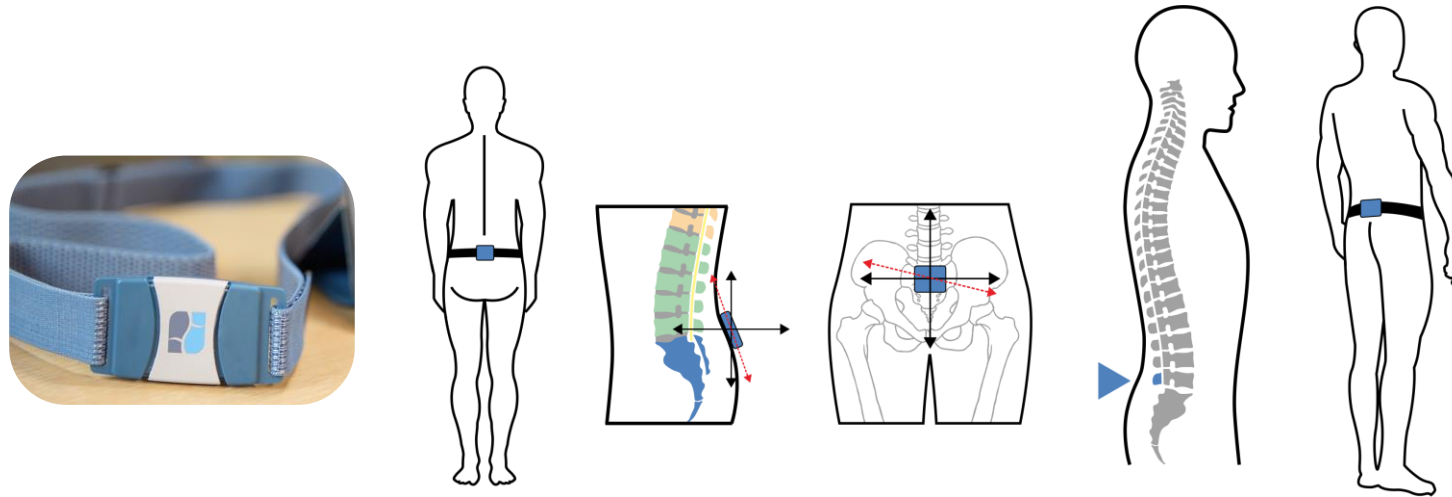


		參考	跌倒風險
睜眼搖擺長度	23.0cm	< 33.4cm	8/10
閉眼搖擺長度	60.7cm	< 38.0cm	1/10
阮柏氏測試			陽性

搖擺長度是身體移動路線的長度總和。搖擺長度越短，穩定性越好。



# Measures Motion and Force from the Center of Mass



*“The body system as a whole may be represented, from a mechanical standpoint, by its CoM<sup>1</sup>.”*

Goldstein H, Poole C, Safko J. Classical Mechanics. 3rd Edn. London, UK: Pearson Education Ltd (2002).

*“Parameters concerned with the BCM<sup>2</sup> are the most important since movements of the BCM are the end result of all the complicated physiological mechanisms and biomechanical events involved in walking.”*

Crowe, Alan & M. Samson, Monique & J. Hoitsma, Marja & A. van Ginkel, Alexandra. (1996). *The influence of walking speed on parameters of gait symmetry determined from ground reaction forces. Human Movement Science.* 15. 347-367.

<sup>1</sup>CoM = Center of Mass

<sup>2</sup>BCM = Body's Center of Mass



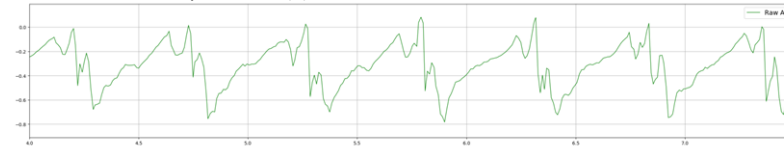
# Aspire Gait Algorithms Background

Results based on Machine Learning Algorithms trained with over 40,000 steps using artificial recurrent neural network

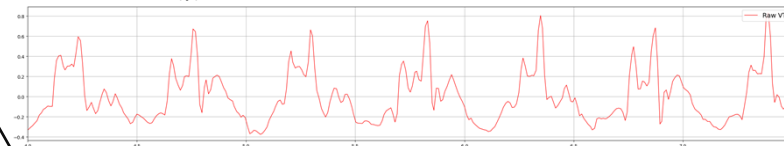
Example of Raw Data

Time	ML	VT	AP
0	0.007737	0.954102	-0.30212
0.008	0.004439	0.96655	-0.30701
0.019	0.00239	0.962524	-0.30688
0.029	-0.00061	0.963257	-0.30957
0.039	-0.00159	0.963501	-0.30433
0.048	0.001465	0.964111	-0.30726
0.058	-0.00098	0.964478	-0.30859
0.068	0.000854	0.962446	-0.31091
0.079	0.002075	0.961384	-0.3103
0.089	-0.00208	0.964111	-0.30701
0.098	0.000977	0.9646	-0.30859
0.108	0.002197	0.9646	-0.30713
0.118	0.000366	0.961792	-0.30481
0.128	-0.00183	0.963013	-0.30566
0.137	-0.00195	0.963745	-0.30908
0.148	-0.00024	0.961426	-0.30781
0.158	-0.00037	0.960205	-0.30762
0.168	-0.00195	0.958984	-0.30615
0.178	0.00061	0.957031	-0.30676
0.187	0.001465	0.95752	-0.30713
0.197	0.002197	0.958618	-0.30664
0.208	0.000854	0.957275	-0.30396
0.218	0.002197	0.958374	-0.3075
0.228	0.004028	0.959473	-0.30652
0.238	0.00354	0.960571	-0.30811
0.247	0.005249	0.969238	-0.30884
0.257	0.005615	0.970459	-0.30688
0.268	0.001343	0.96582	-0.30896
0.276	-0.00342	0.965332	-0.31079
0.287	-0.00208	0.963867	-0.30884
0.297	-0.00098	0.965576	-0.30908

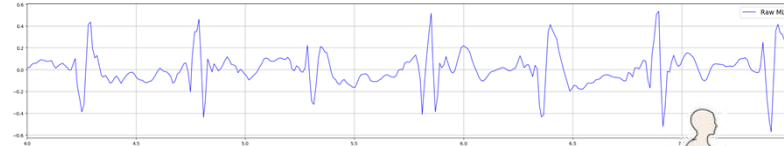
AP – Anterior-posterior (z)



VT – Vertical (y)

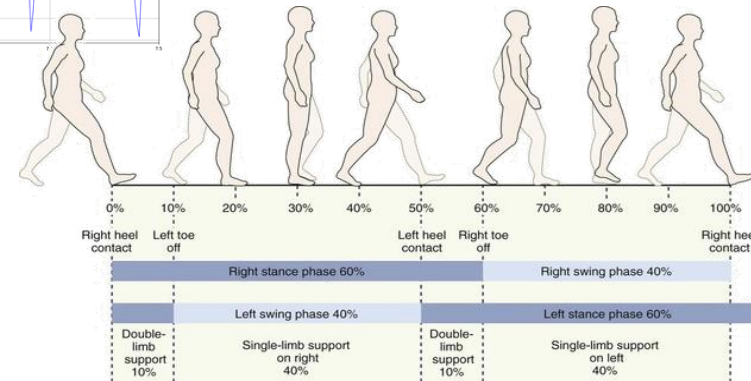


ML – Medio-lateral (x)



1. Distinguishing Left and Right Leg
2. Determine time of Heels Strike and Toe Off for every step
3. Calculate phases and parameters of the Gait Cycle

Normal and Reference ranges are based on published journal values and adjusted using Asia population specific database.

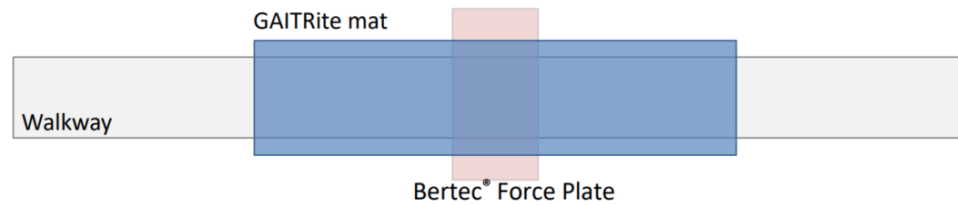


Traditional subdivisions of the gait cycle. (From Neumann DA: Kinesiology of the musculoskeletal system: foundations for physical rehabilitation, ed 2, St Louis, 2010, Mosby, Figure 15-11.)





# Golden Standard Comparison

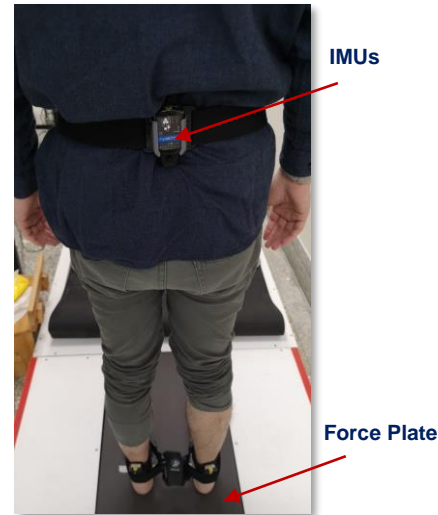
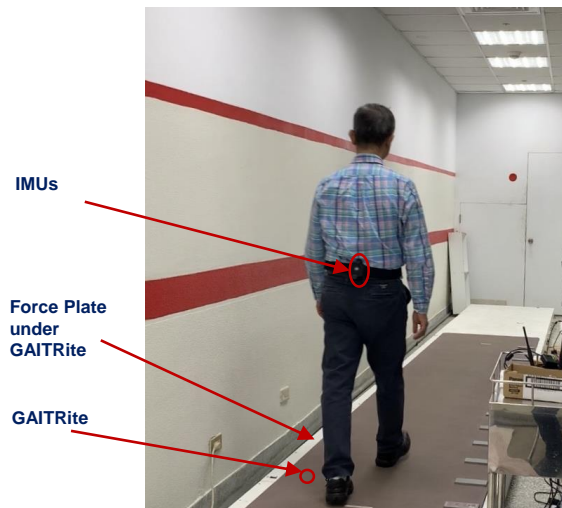


## Aspire™ vs. GAITRite® :

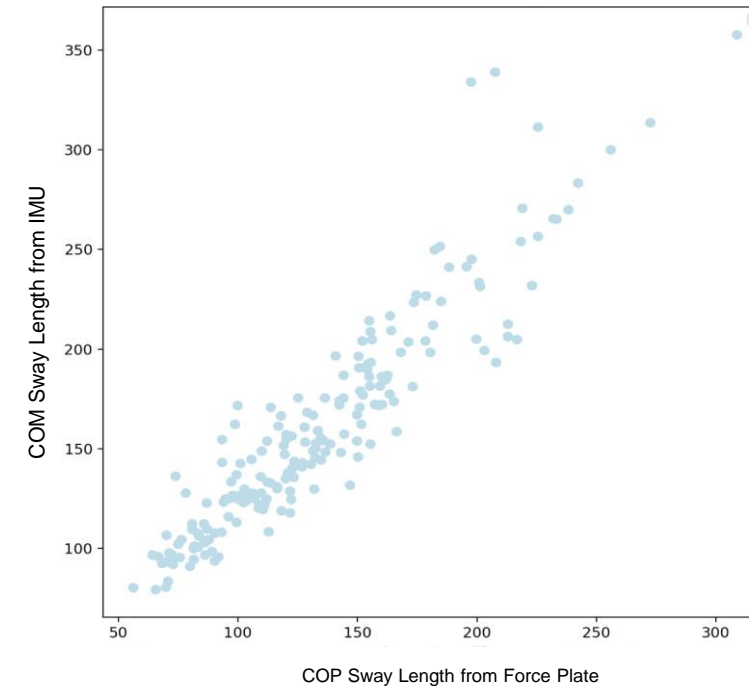
- Heel-strike time:  $\pm 10\text{ms}$
- Toe-Off time:  $\pm 30\text{ms}$

190個樣本 年齡位於 28 - 72

Pearson's coefficient:  $r=0.93$



- 同步傳感器數據
- 51位對象 x 5個樣本
- 4位對象 x 10個樣本

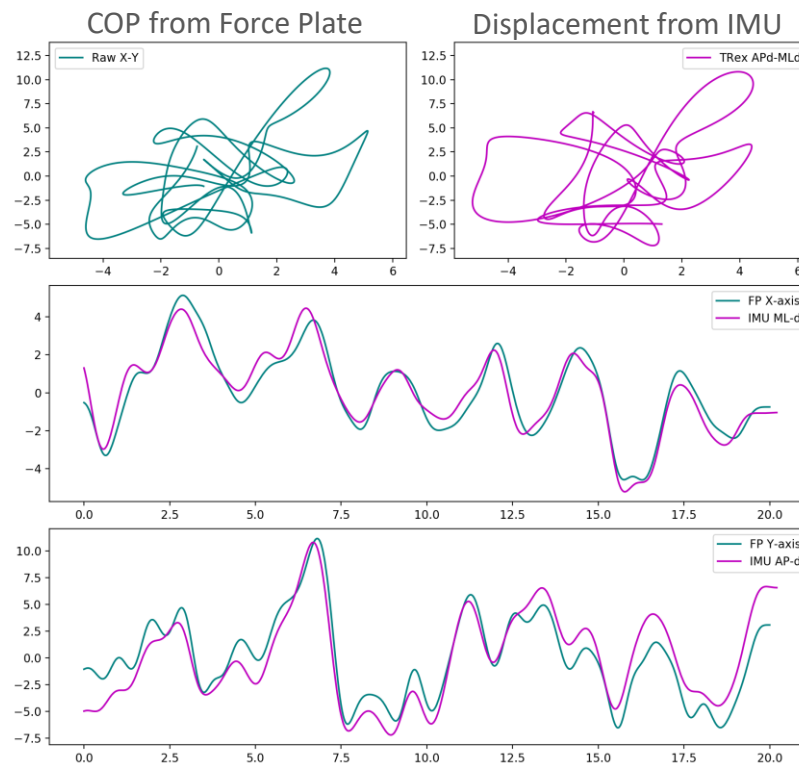




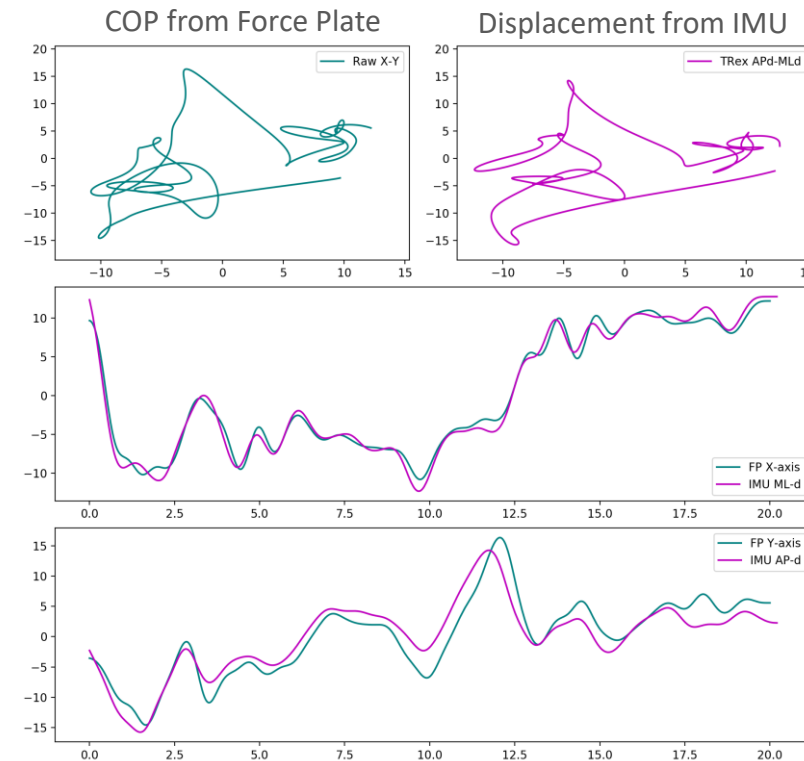
# Postural Sway validation example with Bertec® Force Plate

Teal = Force Plate  
Magenta = Booguu IMU Algorithm

70 Year Old Female (EC)



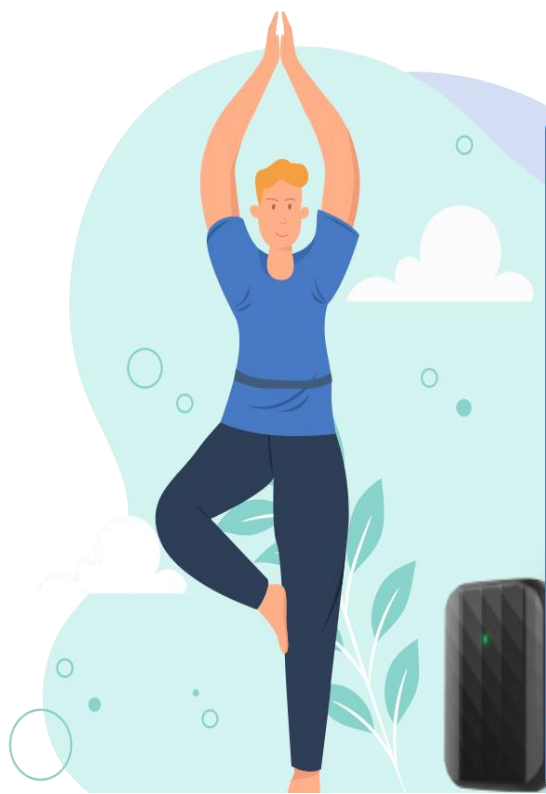
61 Year Old Male (EO)





# ASPIRE BALANCE™

## 追蹤及提高平衡能力





# Four Foundational Balance Stances

Each of these stances are important for healthy living. Each test assesses the various aspects needed for good balance and stability.



1. Feet Together

- Baseline test of overall balance control.
- Common factors such as medication, certain food and drinks, stress, and a poor night of sleep can impact our balance.



2. Tandem

- Tests lateral balance control of the ankles, hips, core, and leg muscles.
- Impaired lateral stability is a key fall factor among older adults.



3. Single Leg

- Important for general health and fitness.
- Tests the necessary foundation to support body motion.
- Healthy individuals should be able to maintain single leg balance for at least 20 seconds.

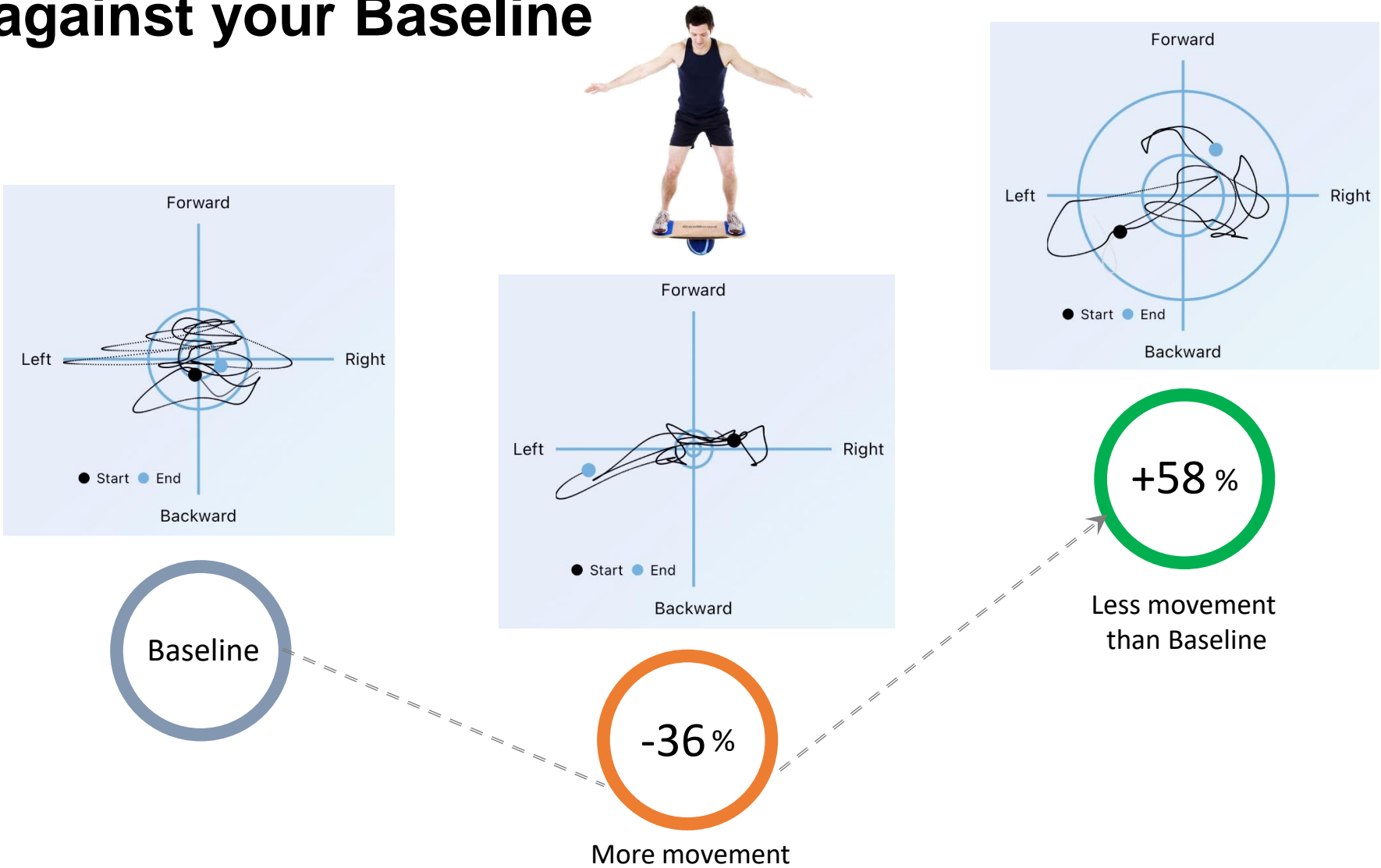


4. Single Leg Side Raise

- Targets the key muscles that stabilize the hips.
- Having good hip stability can reduce hip, knee and foot injuries.
- Maintaining this posture requires a strong core and can help with posture.



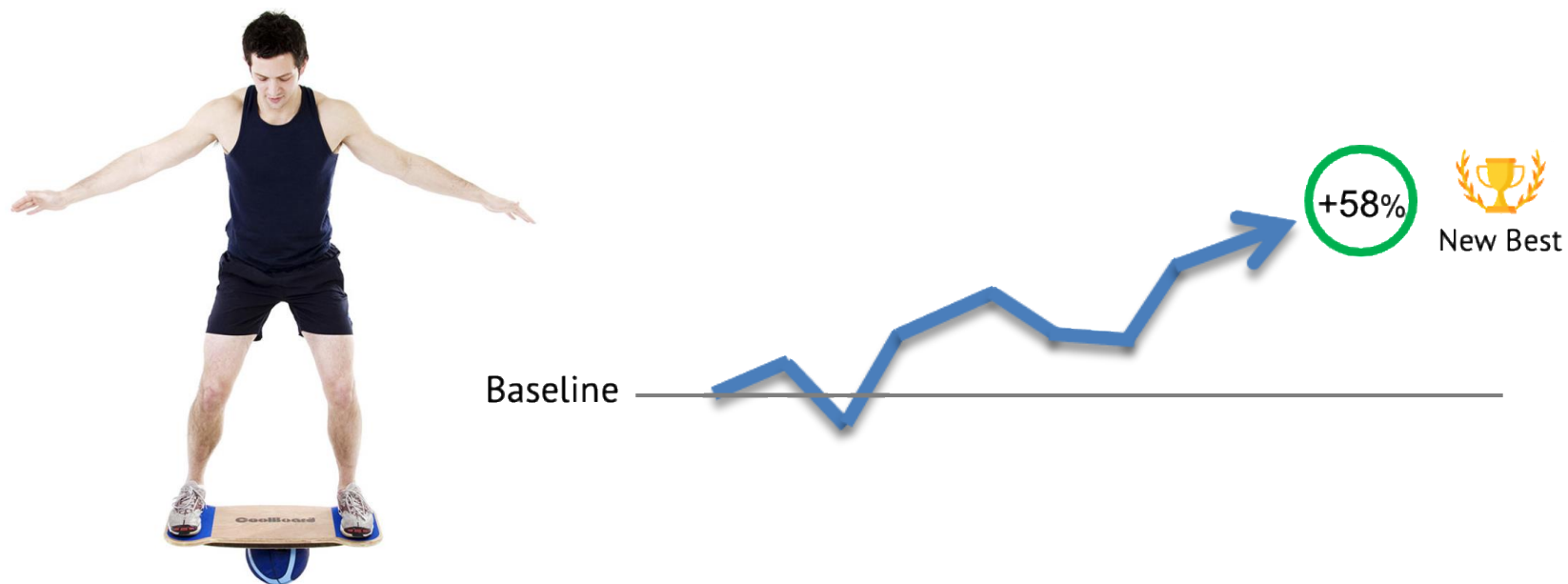
# Compete against your Baseline







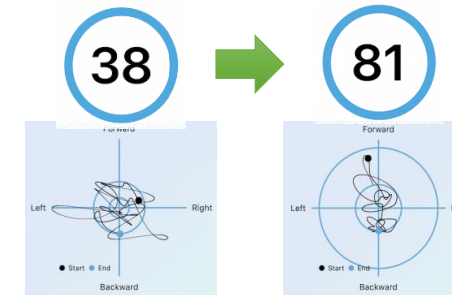
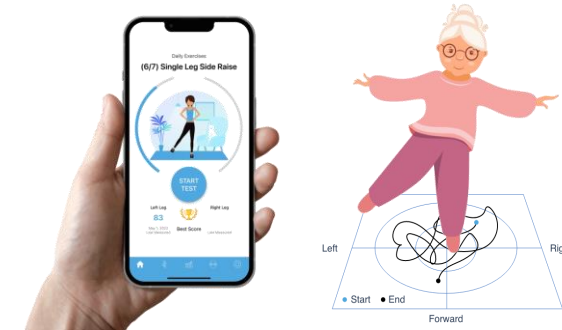
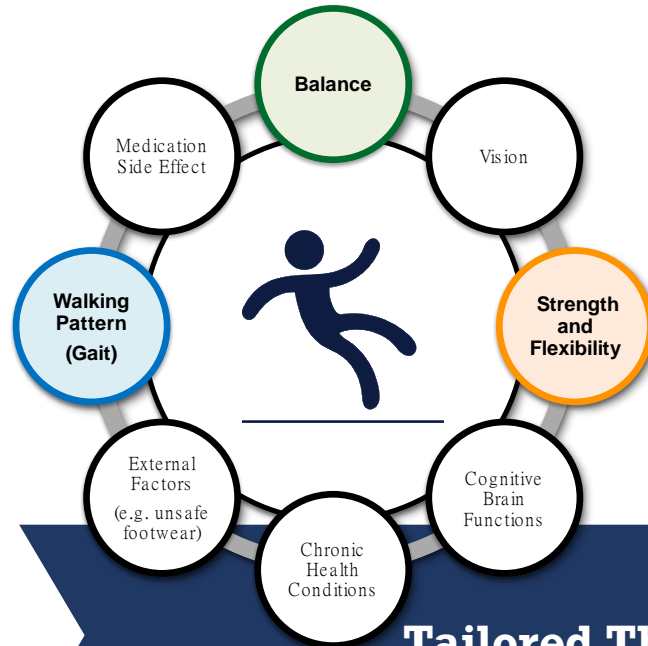
# Track Your Improvements





# PREVENTIVE THERAPY & MONITORING

*Beneficial for 8 out of 10 elders over the age of 65*



Visualizing improvements

**Tailored Therapy, Home Exercise, Orthotics, Nutrition**



**Track Progress & Outcome  
Remote Assessment and Monitoring**





# STEP 1: RAPID COMMUNITY BASED RISK Management

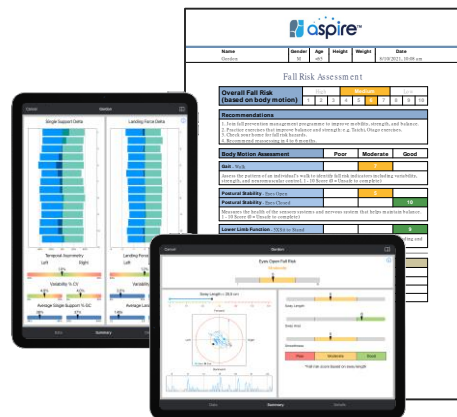
1 Sensor

3 Tests

5 Minutes



1. 30 steps Walking Gait
2. 30 seconds Balance
3. 15 seconds Lower Body Function



- Screen elderly for fall risk in community centres and in-home setting.
- Operable by volunteers, even those in their 60s and 70s.
- Results shared remotely with healthcare professionals for recommendations and actions.

**Identify Subclinical Risk Group in Community Settings for Early Prevention**



# STEP 2: REMOTE THERAPY MONITORING

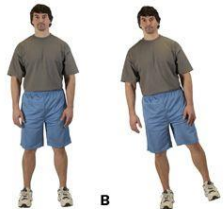
## Home Exercise program



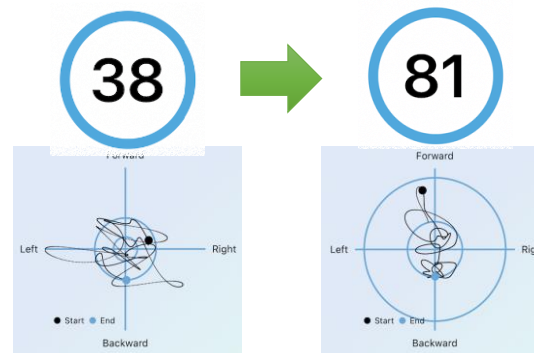
Hold 30 Seconds  
**Complete** 3 Sets  
**Perform** 2 Times a Day



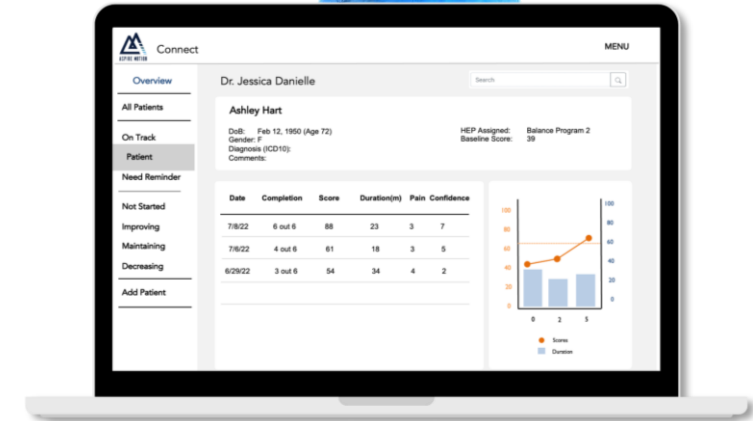
Hold 15 Seconds  
**Complete** 3 Sets  
**Perform** 1 Times a Day



Hold 30 Seconds  
**Complete** 3 Sets  
**Perform** 1 Times a Day



Visualizing improvements over time



**Assign Home Exercise Program (HEP)**

**Instant Feedback & Tracking**

**Review and Adjust Therapy**

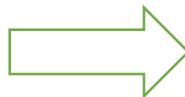




### Founded in 2016 by Prof. Jeffrey Cheung, Hong Kong Baptist University (HKBU)

- PhD Harvard University
- Oak Ridge National Laboratory & Rockwell International Science Center
- Distinguished Visiting Professor, Dept of Physics, HKBU
- Spin-off from HKBU
- Focused on health application using IMU and motion analysis since 2014
- Incubated at Hong Kong Science and Technology Park (HKSTP)
- Healthy Ageing Platform and Gerontechnology Platform of Hong Kong
- R&D and Sales Teams in US and Asia
- 2 US and 1 China patents awarded, and multiple patents pending

### Shaky Minibus



### Award Winning Research and Product on Gait & Balance





# AWARD WINNING



- 3 Gold & 1 Silver Medals at Geneva International Exhibition of Inventions 2017 and 2021
- TechConnect Business Innovation Award, US TechConnect Summit 2020
- Hong Kong Information and Communication Technology (ICT) Smart Living Merit Awards 2020
- Hong Kong Jockey Club Age Friendly Innovation Merit Award 2020
- Gold & Grand Award at Invention Asia Hong Kong 2019



## Contact

[info@booguu.bio](mailto:info@booguu.bio)

**Tel: 3590 2685**

### ***Aspire Fall Risk Management***

智能腰帶 簡單動作 5分鐘 評估潛在跌倒風險

<https://youtu.be/W2IAZzP8H5U>

### ***Aspire Balance***

登峰智能平衡健體環

<https://youtu.be/XZymqZX85UM>

<https://www.balance.aspiremotion.com/balance-help-videos>

### ***Aspire Motion Connect***

步固登峰動態健康聯網

<https://youtu.be/RbBeDz1rTz4>



# 智能穿戴及鐘錶科技中心 Smart Wearables, Watch and Clock Technology Centre

The Hong Kong Productivity Council (HKPC)

Aug 2023



## Smart Wearables, Watch and Clock Technology Centre

(formerly the Hong Kong Watch & Clock Technology Centre), established with the ITF funding of the Hong Kong SAR Government, is jointly managed by the Hong Kong Productivity Council (HKPC) and the Hong Kong Watch Manufacturers' Association Limited (HKWMA).

- Smart Wearables, Watch and Clock Technology Centre provides a comprehensive range of consultancy and support services for the smart wearables, watch & clock industry. The Centre offers testing service for:
  - Smart wearables
  - Quartz and Mechanical watches
  - Parts and Components

**Over 50 different testing services for Smart Wearables, Watch and Clock**





# Mission

- Assist the local smart wearables, watch & clock industry to strengthen their competitiveness and leading position in the global market.
- As a central body to transfer relevant technologies to support Hong Kong manufacturers
- Provides independent testing services in quality assurance, particularly in areas where tests are unavailable commercially, to improve product quality and management capabilities.



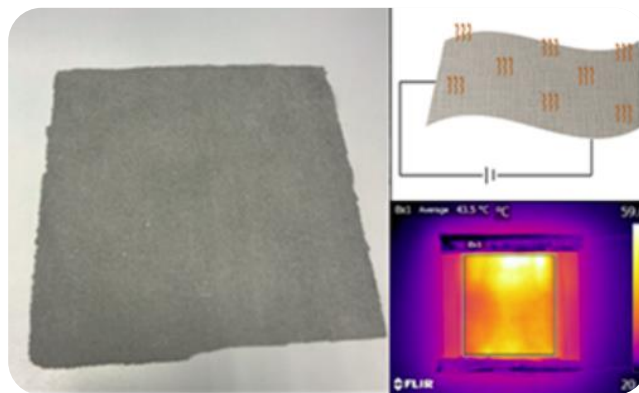




## Technology Development Services



- Smart Wearables Technology
- Customised Watch Testing Equipment
- Smart Manufacturing Technology
- Plastics and Composite Technology
- Metals Processing Technology
- Surface Finishing Technology

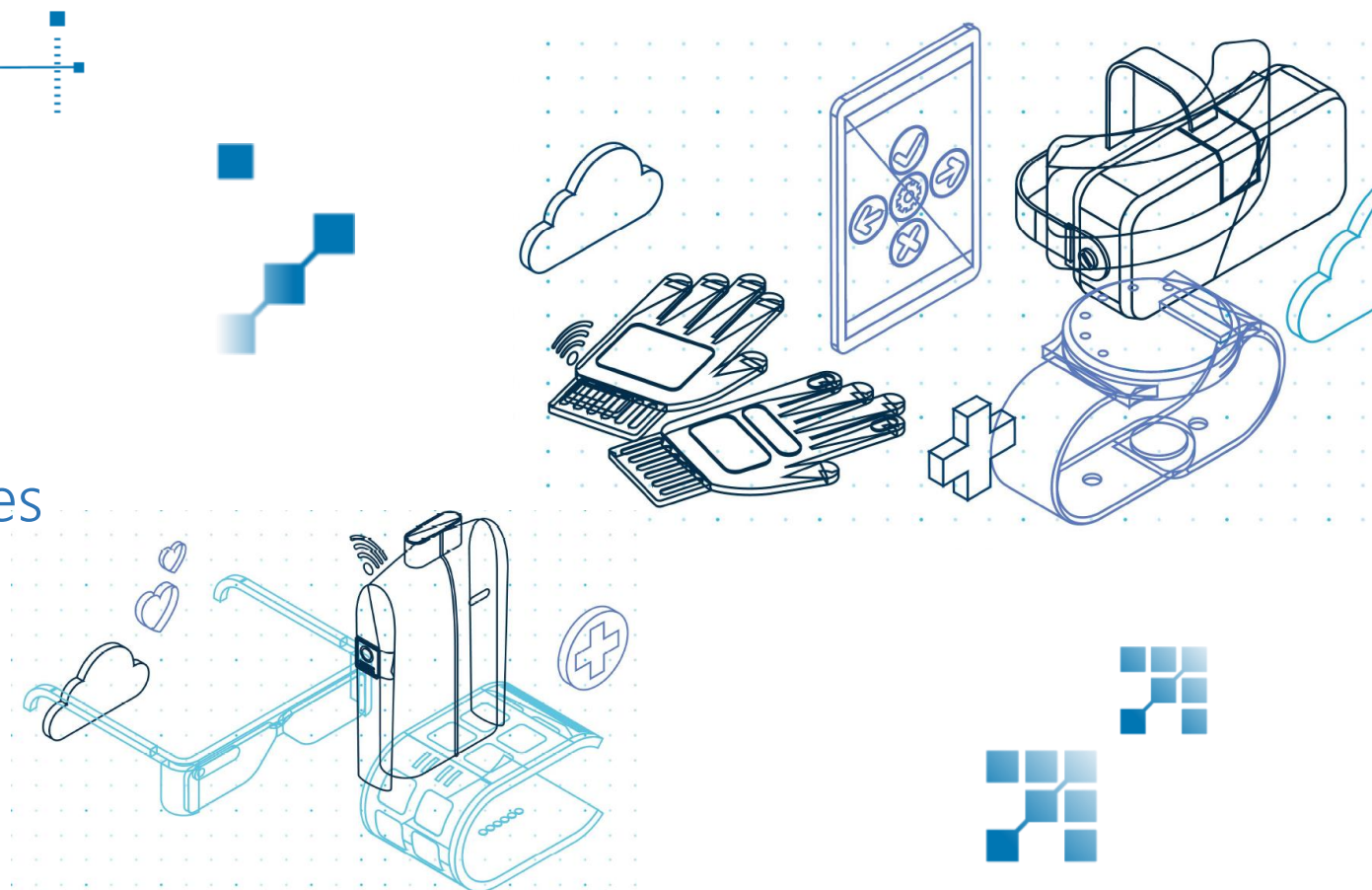




## Testing and R&D services are open to public

For industry,

- Watch & Clock
- Electronics
- Fashion & Textile
- Jewellery & Accessories
- Eyewear & Glasses
- Medical & Healthcare
- InnoTech & Startups





## Performance Assessment

- Step Counting
- Heart Rate
- Blood Pressure
- Oxygen Content in Blood



All above accuracy assessment tests are performed by advanced systems, which simulate the human activities with the actual human dynamic data and physiological values collected in advance.







## IoT Cyber Security Assessment



(Supported by Hong Kong Digital Testing Hub, HKPC)



## Reliability Testing

- Environmental Stress Testing
- Printed Circuit Board Testing
- Design of Accelerated Life Test, Life Data Analysis such as Weibull Analysis

## Electromagnetic Compatibility Testing

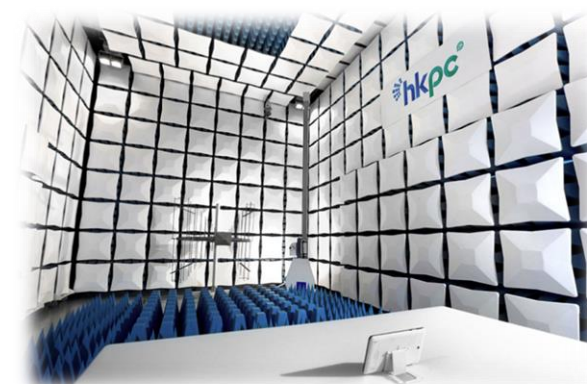
- Emission testing
- Radiated and conducted immunity testing
- ESD immunity testing

## Wireless Product Testing

- CE/FCC testing



(Supported by Reliability Testing Centre, HKPC)



(Supported by Electromagnetic Compatibility Centre, HKPC)



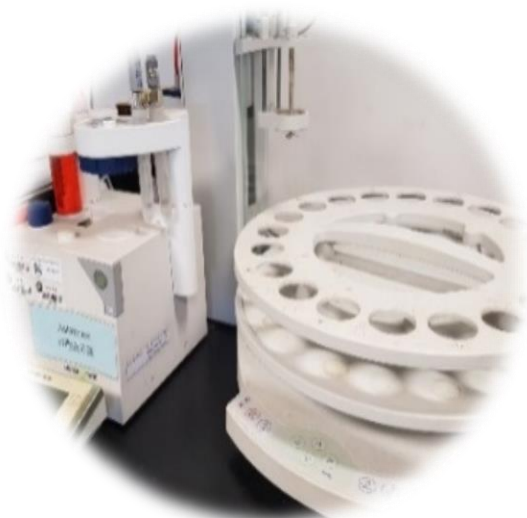
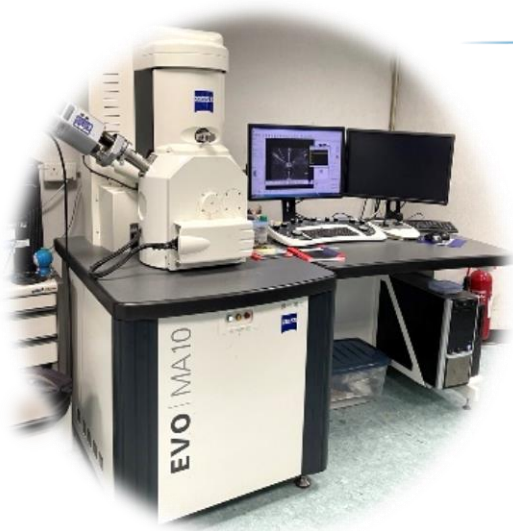
(Supported by Wireless Testing Centre, HKPC)





## General Testing

- Mechanical Test
- Biological Test
- Physical Test
- Chemical Test





## XR Technology Application

### Career Pathways related to Wearable Technology, Industry support and cases sharing

Speaker:

Mr. Brendon Yu

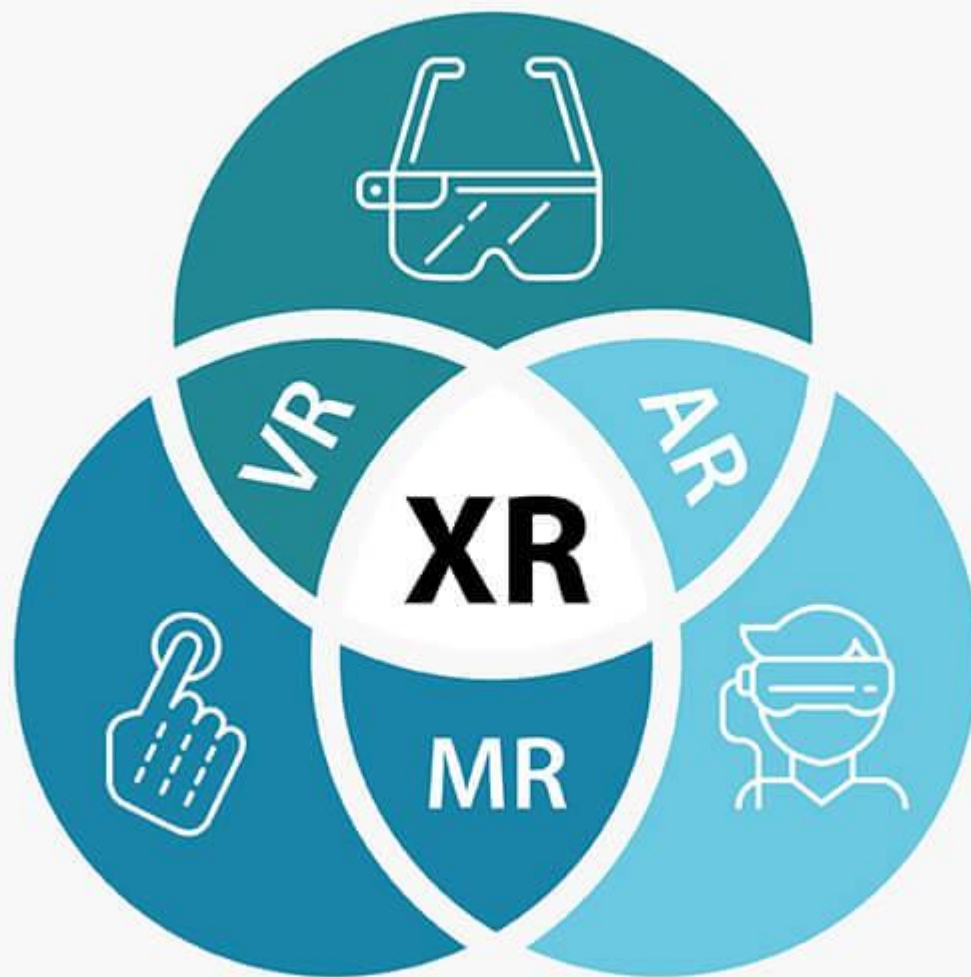
Consultant,

Metals and Industrial IoT Technology,

Smart Manufacturing Division,

Hong Kong Productivity Council







## XR Extended Reality

### AR

Augmented Reality

擴增實境 (AR) – 旨在透過有限互動在真實世界檢視上新增數位元素。

### VR

Virtual Reality

虛擬實境 (VR) – 沈浸式體驗有助於將使用者與真實世界隔離開來，通常是透過為此類活動設計的頭戴式裝置和耳機。

### MR

Mixed Reality

混合實境 (MR) – 結合 AR 和 VR 元素，使數位物件可以與真實世界互動，這意味著企業可以設計錨定在真實環境中的元素



## VR技術應用



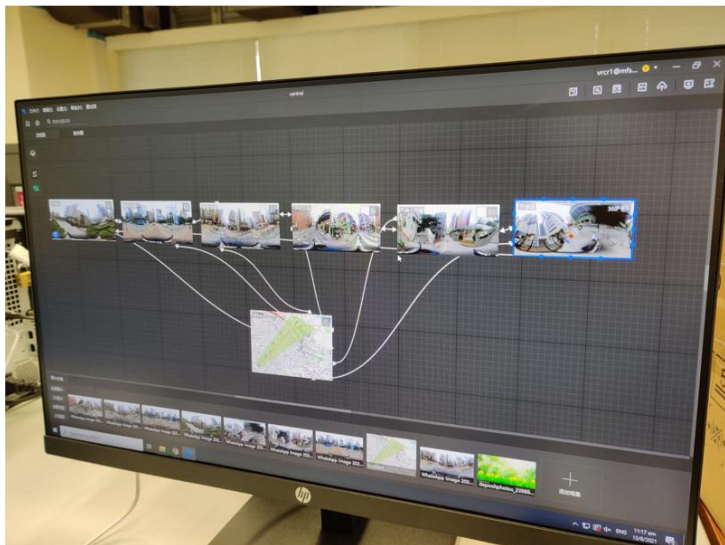
遊戲

旅遊

教學

醫療



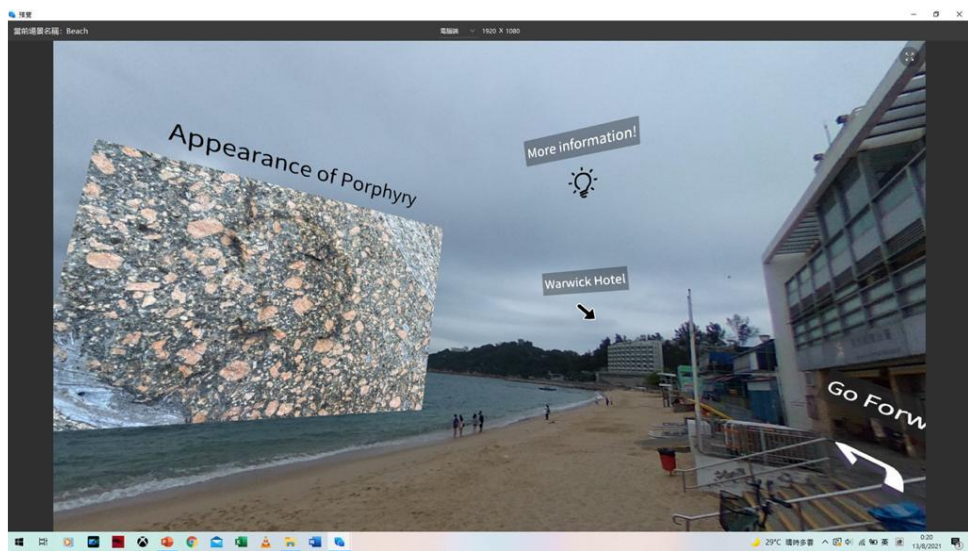


場景位置設計

個別場景設計

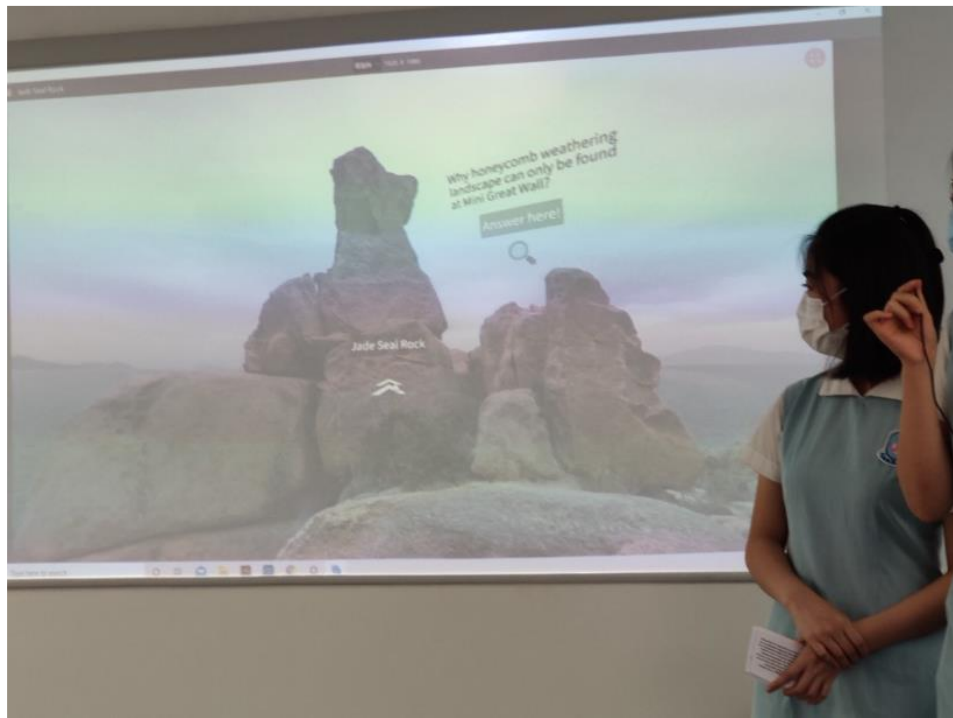


VR場景生成





- ▣ 老師
  - ▣ 虛擬考察
- ▣ 學生
  - ▣ 匯報





## MR技術應用



佈局設計

3D模型預覽

教學

看板



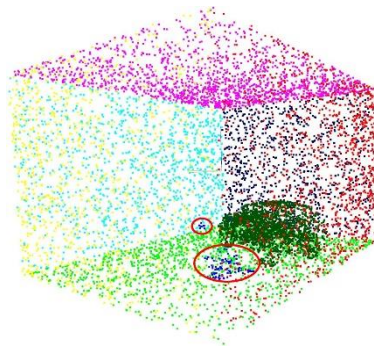


Digital Twins  
model  
數位對映

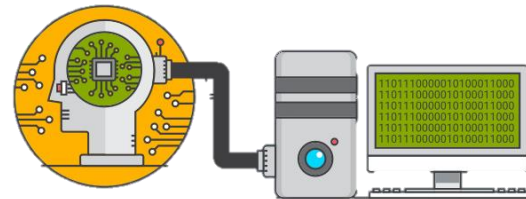




現實場景



點雲數據



現實場景



3D 模型

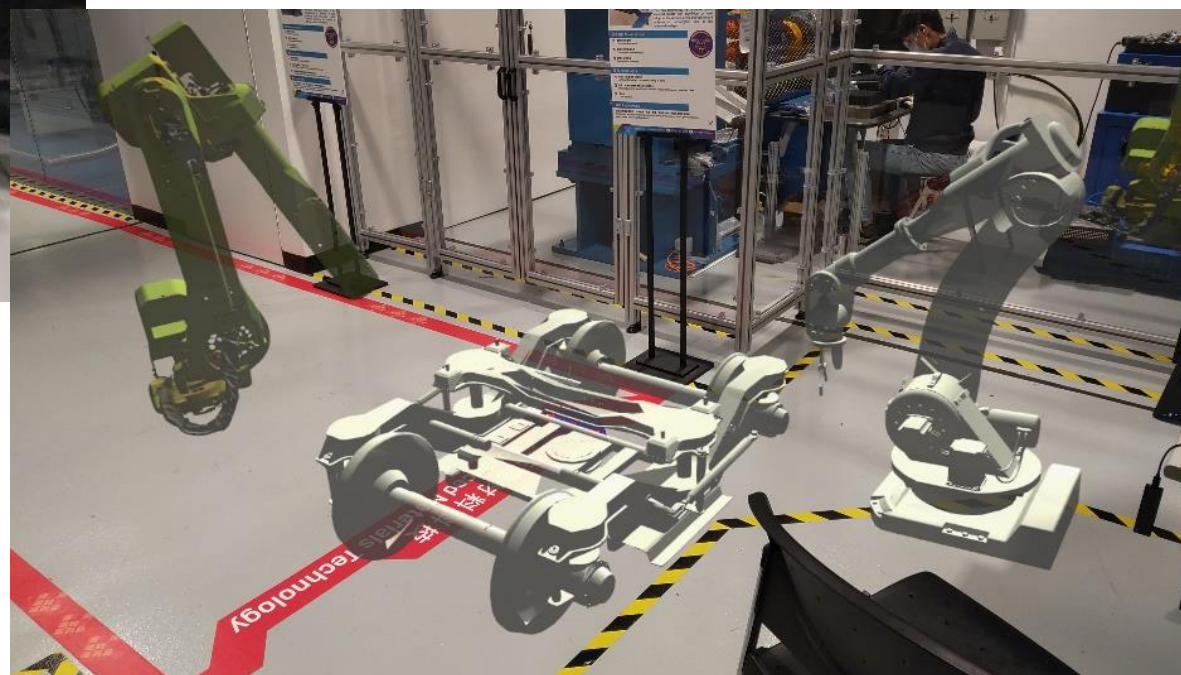


頭戴式設備



混合實境





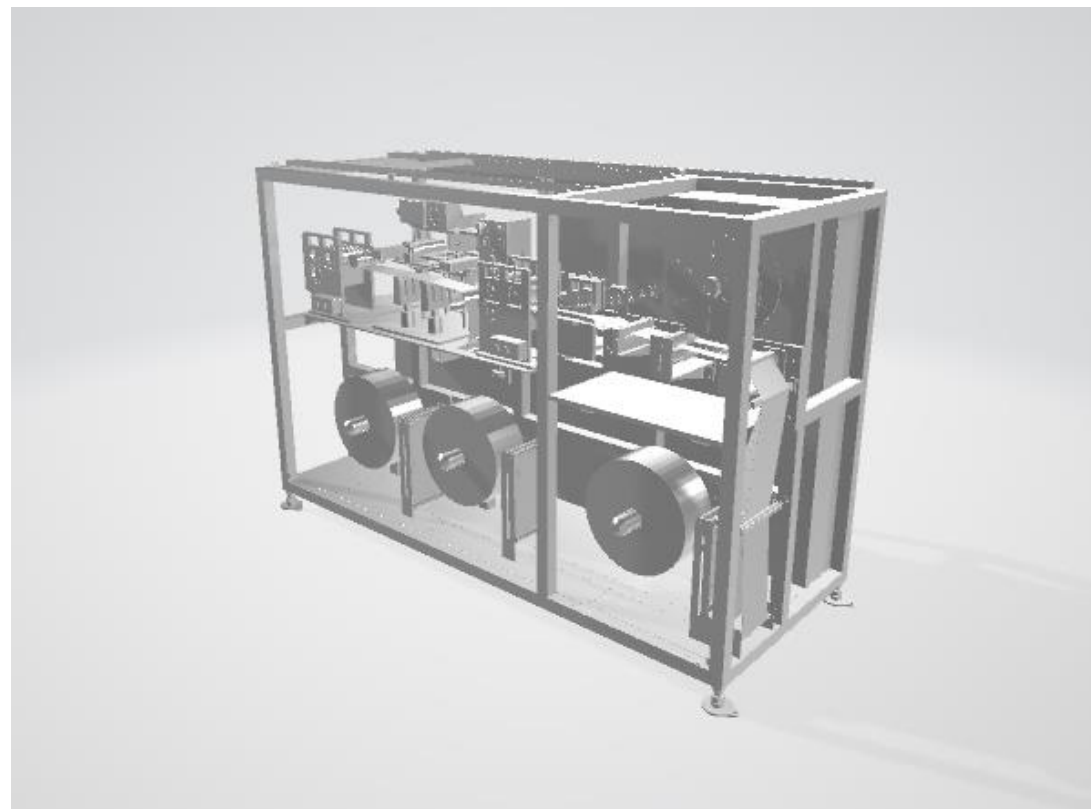


- ▣ 實時設計預覽
  - ▣ 檢測碰撞
- ▣ 量度距離
  - ▣ 物件操作





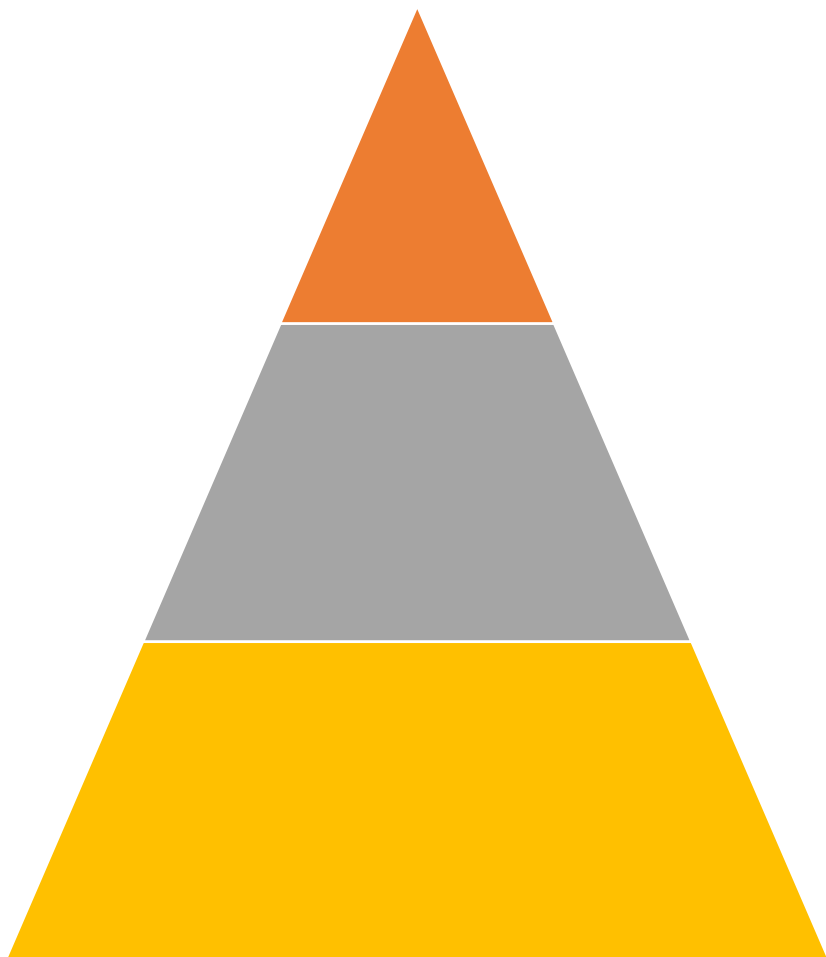
## MR企業支援







- 預覽機器
- 估算機器大小
- 任何地方展示



XR設備工程師  
XR平台工程師

程序開發員  
Unity 開發員

產品設計師  
多媒體設計師  
3D設計師





多媒體設計師  
3D設計師

持有多媒體、遊戲、平面設計或相關學科的文憑或以上

- 設計學(榮譽)文學士組合課程 (PolyU)
- 創意媒體高級文憑 (VTC)

甲類：核心及選修科目

- 設計與應用科技
- 資訊及通訊科技
- 視覺藝術

相關技能

- Maya
- UI/UX 設計
- Adobe系列軟體
- 具有Unity或其他3D遊戲引擎的知識



程序開發員  
Unity 開發員

電子工程或計算機科學的學士學位或以上

- 計算機科學與工程 (CUHK)
- 工程學 (HKUST)
- 資訊及人工智能工程學(榮譽)工學士 (PolyU)

甲類：核心及選修科目

- 數學 (延伸部分)
- 生物
- 化學
- 物理
- 資訊及通訊科技

相關技能

- C#, Unity 3D, C/C++, Python
- 具備在遊戲引擎中進行編程的知識  
包括Unreal Engine或Unity



**XR設備工程師**  
**XR平台工程師**

計算機科學、電子工程、信息工程、數學、物理或其他相關領域的學士學位或以上

- 計算機科學與工程 (CUHK)
- 工程學 (HKUST)
- 資訊及人工智能工程學(榮譽)工學士 (PolyU)
- 理學士(物理學) (CityU)

甲類：核心及選修科目

- 數學(延伸部分)
- 生物
- 化學
- 物理
- 資訊及通訊科技
- 設計與應用科技

相關技能

- C#, Unity 3D, C/C++, Python
- 機器學習和人工智能算法
- 圖像和視頻編解碼器  
例如JPEG、WebP、AVIF、H.26x、AV1、AVS3
- 低延遲的視頻傳輸協議



# Thank you

**Hong Kong Productivity Council**  
**香港生產力促進局**

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