

Advances in Sport Technology for Human Health and Performance

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6 December 2024



Sports Technology...



“Sports Technology” refers to methods, systems, devices, and any sporting equipment which being used to help prevent **sports injuries** and **optimise performance**

Track Bike for 2020 Olympics



Team GB



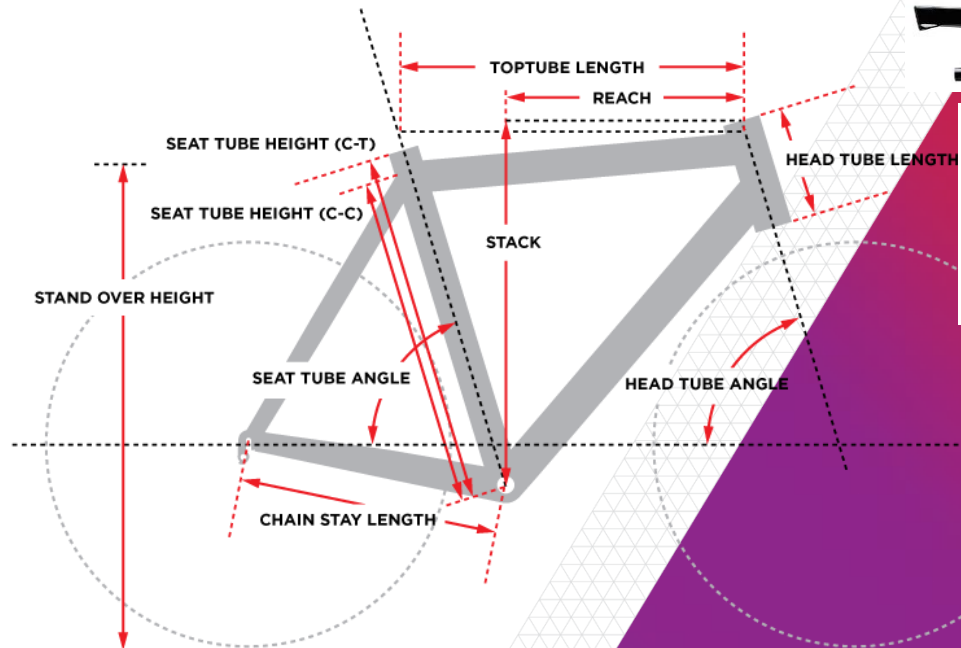
Team Netherland



Team Denmark, Australia,
Canada



Team USA



1. Appropriate Equipment Protection:

- Impact garments, helmets, mouth guards, and other protective gear.
- Utilising advanced materials and design to enhance athlete safety.

2. Technical and Risk Assessment (before injury):

- Motion analysis techniques to assess movement patterns and identify potential risks.
- Assessing muscle strength, range of motion, and conducting imaging tests like MRI, ultrasound, and infrared thermography.



3. On-Training Load Monitoring:

- Wearable devices to track training loads.
- Utilising computer vision techniques for facial and posture recognition to assess form and technique.

4. Effective Recovery Measures:

- Recovery techniques such as water baths, cryotherapy, pulsed electromagnetic field (PEMF) therapy, hyperbaric oxygen therapy, and vibration platforms.
- These measures help promote tissue healing, reduce inflammation, and improve muscle recovery.

5. Big Data Analysis:

- Centralised databases that integrate training records, nutrition data, and other information.
- Utilising artificial intelligence and predictive analytics to analyse this data and identify patterns and trends to optimise performance and prevent injuries.

6. Robot Assisted Devices:

- Using robots to assist in the training of elite athletes to improve effectiveness and prevent injury.
- Able to simulate different conditions otherwise not possible.

1. Appropriate Equipment Protection:



Latest Equipment: Smart Mouth Guard



Built-in impact sensors alert the athlete the degree of head impact (**Red – devastating blow**, **Blue – medium impact**, **Green – low impact**)



For immediate follow up

- take a rest
- medical consultation

Competition Suits (Rowing)



Cooling Cap



- Preventing Heatstroke and UV Protection

Competition Suit



1. Appropriate Equipment Protection:

Latest Equipment: High-tech Helmet



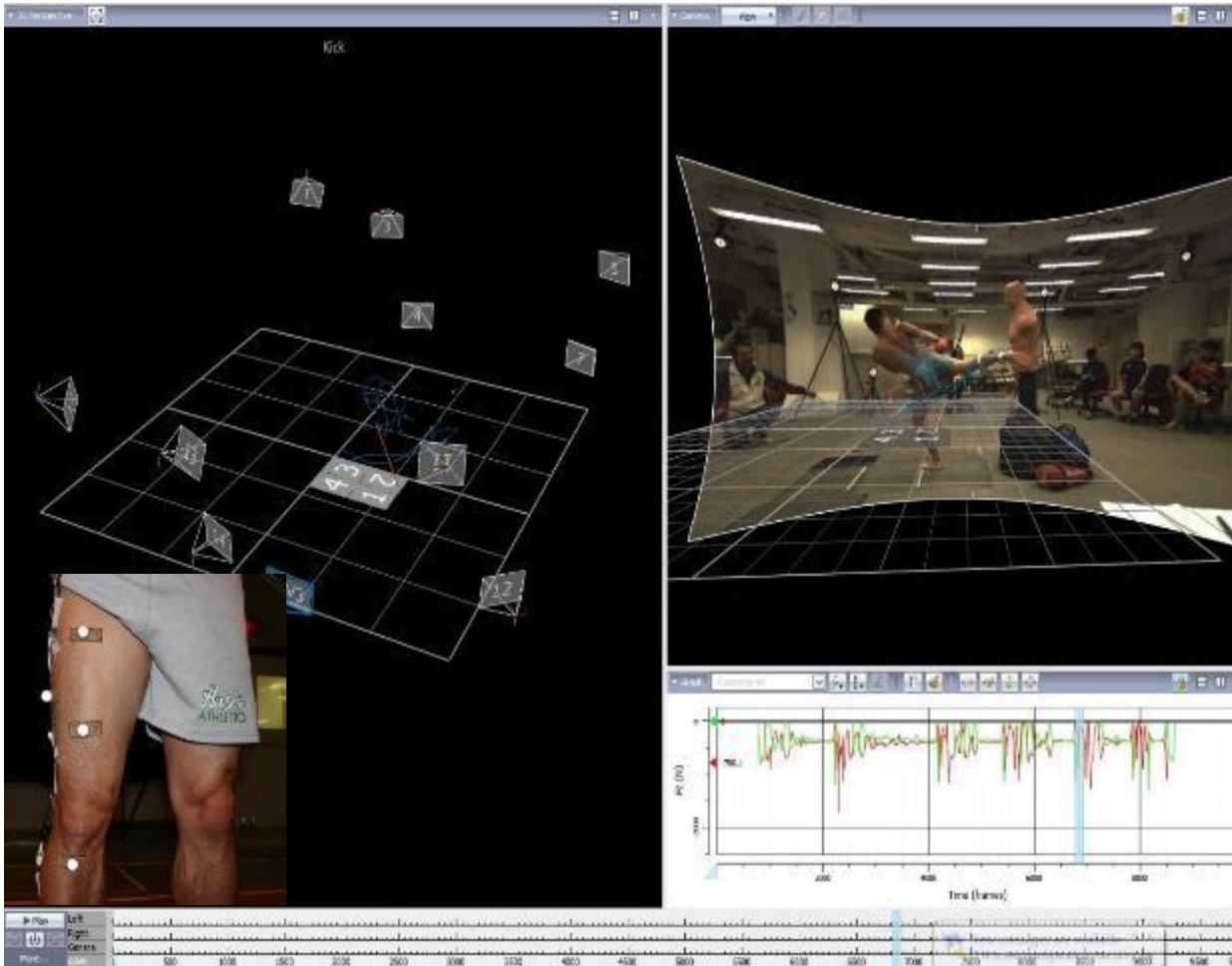
Advanced material and design for reducing injury risk potential

9 Jun 2023

Stanford University scientists have developed a helmet for American football players that contains liquid shock absorbers that could reduce the impact of blows to the head by one-third.

All these technologies allows athletes to **stay healthy**, **injury-free** and **improve performance** during training and competition

2. Technical and Risk Assessment: Movement analysis (marker-based)



Well established standard to evaluate key injury factors

- Poor posture
- Excessive Joint loading
- Inappropriate kinetic chain
- abnormal EMG pattern (muscle weakness)



Reduce injury risks by optimise balance of applied and absorbed external loading

2. Technical and Risk Assessment:

Movement analysis (video-based)



Calibrated with marker-based system for posture and skill analysis

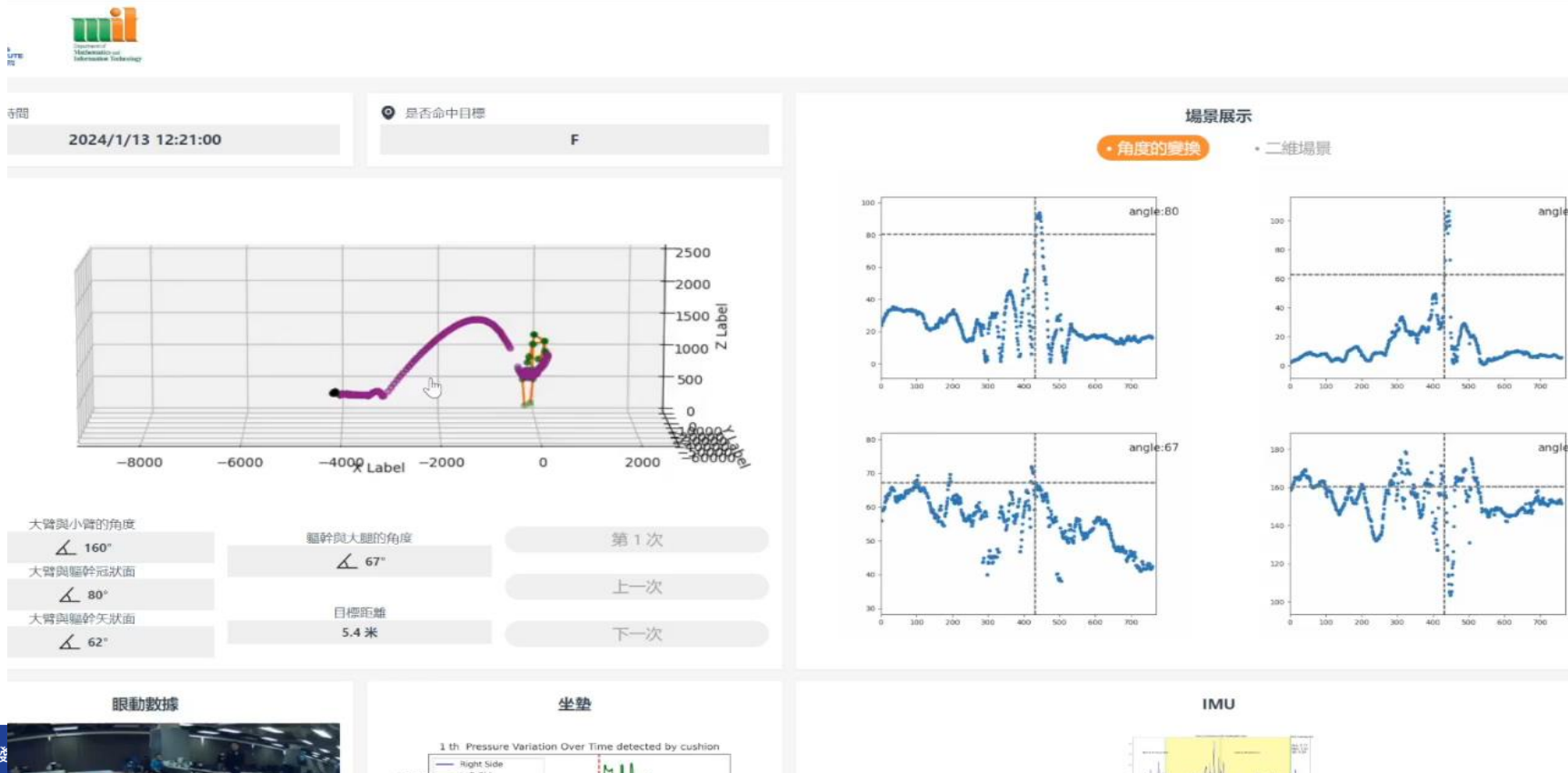
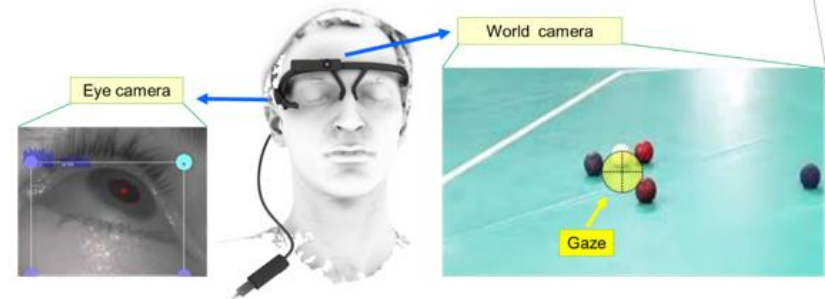
No physical or psychosocial constraint

Reduce athlete preparation time allowing regular check

2. Technical and Risk Assessment:

Boccia Training System (markerless-based) (under development):

To provide synchronized eye gaze, ball and movement analysis for training at HKSI and field test



2. Technical and Risk Assessment:

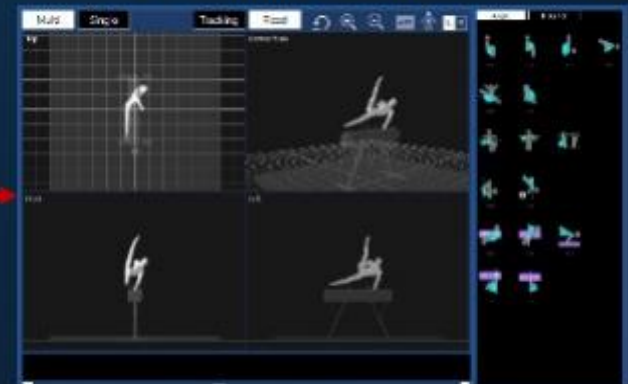
Advance Computer Vision – Markerless Motion Analysis (minimal human operation)

Overview and features of AI gymnastics scoring system

FUJITSU

Helping judges to judge more accurately

View the performance from all 360 degree angles

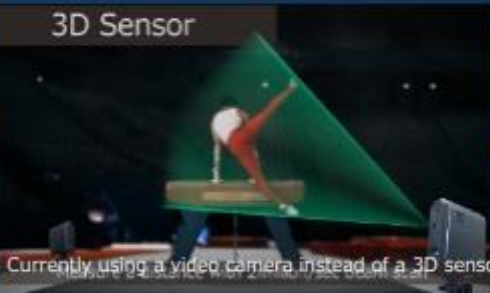


Displays the angle of legs, jump height, etc.



Convert gymnastics performance to 3D data

3D Sensor



Currently using a video camera instead of a 3D sensor

Get 3D data of acting without markers

Skeleton Recognition



Derive the 3D positions of the body's main joints

AI locates human joints and recognizes skeleton

- **Recognised human pose for different sports**
- **Supervised AI training approach**
- **Machine learning to classify performance quality and injury risk potential**

2. Technical and Risk Assessment: Nordbord (hamstring test)



- Nordic Hamstring Exercise to measure the torque/force of hamstring

- To detect **bilateral limb asymmetry**

- Asymmetry $> 15\%$ has an increased risk of a hamstring strain injury



2. Technical and Risk Assessment (before injury):

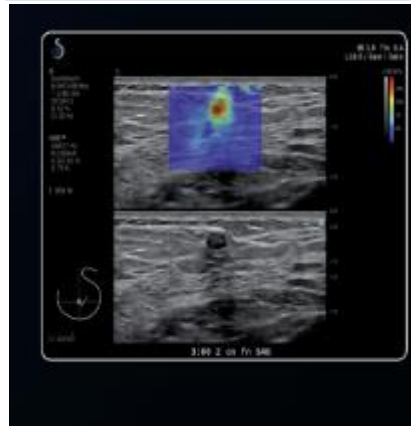
Advance Imaging Modality

US Imaging for tissue morphology



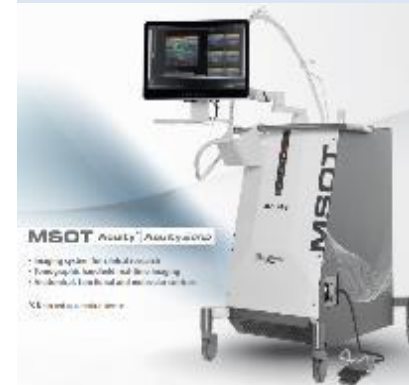
Ultrasound
Volume imaging

US Imaging for tissue elastic properties



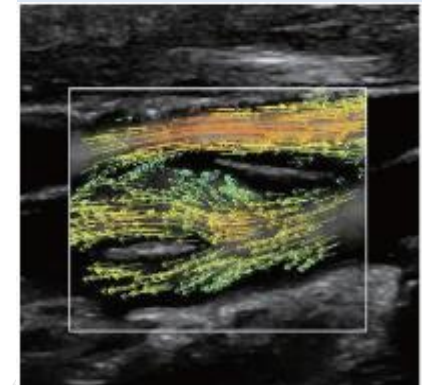
US Elastography

US Imaging for tissue composition (oxygenation)



US Photoacoustic
imaging

US imaging for tissue microcirculation



US Vascular
hemodynamics

Thermal Imaging for inflamed tissues



Infrared thermography

Through comprehensive injury risk assessments, the advance recovery technologies and appropriate injury prevention programs can be implemented to **strengthen the competitiveness** of athletes

AI in Sports



1. "AI in Sports: How Artificial Intelligence Impacts the Sports Industry?", <https://www.vlinkinfo.com/blog/ai-in-sports/>

The Interrelationship Between Big Data, Machine Learning, and AI in Sports

**Big Data
(Data Sources)**



**Machine Learning
(Data Analysis)**



**Artificial Intelligence
(Decision Making)**

- Player performance metrics and health data
- Video / Camera
- Sensors / Wearable Gadgets
- Game Statistics
- ...

- Pattern Recognition
- Predictive Models
- Performance Insights
- Injury Risk Assessment
- ...

- Automated
- BioInsightsmechanical analysis
- Strategy Optimization
- Injury Prevention
- ...

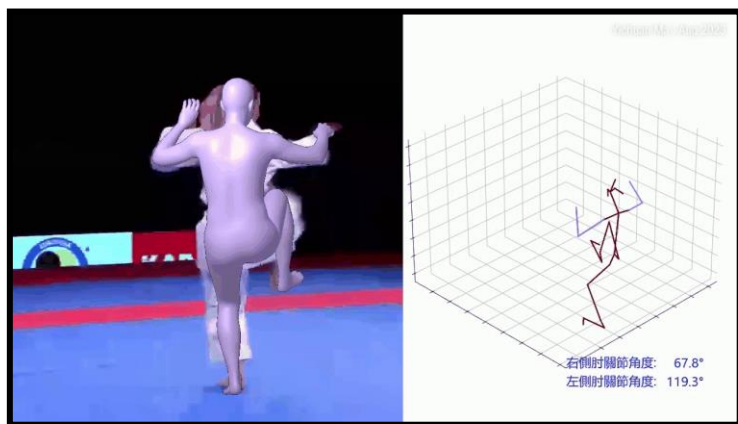


Catapult

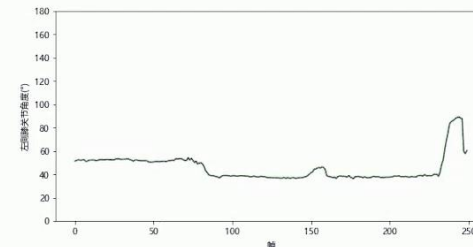
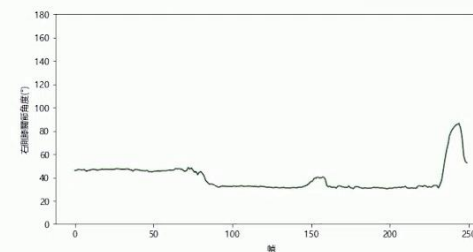
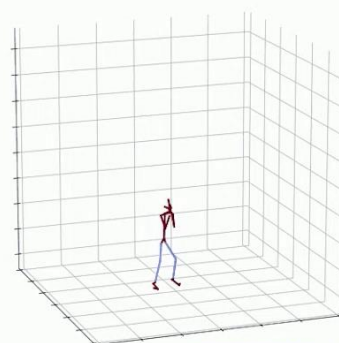


SWING VISION

Project 5 - Training Tools for Karate Athletes Using Markerless Motion Capture and AI Technology



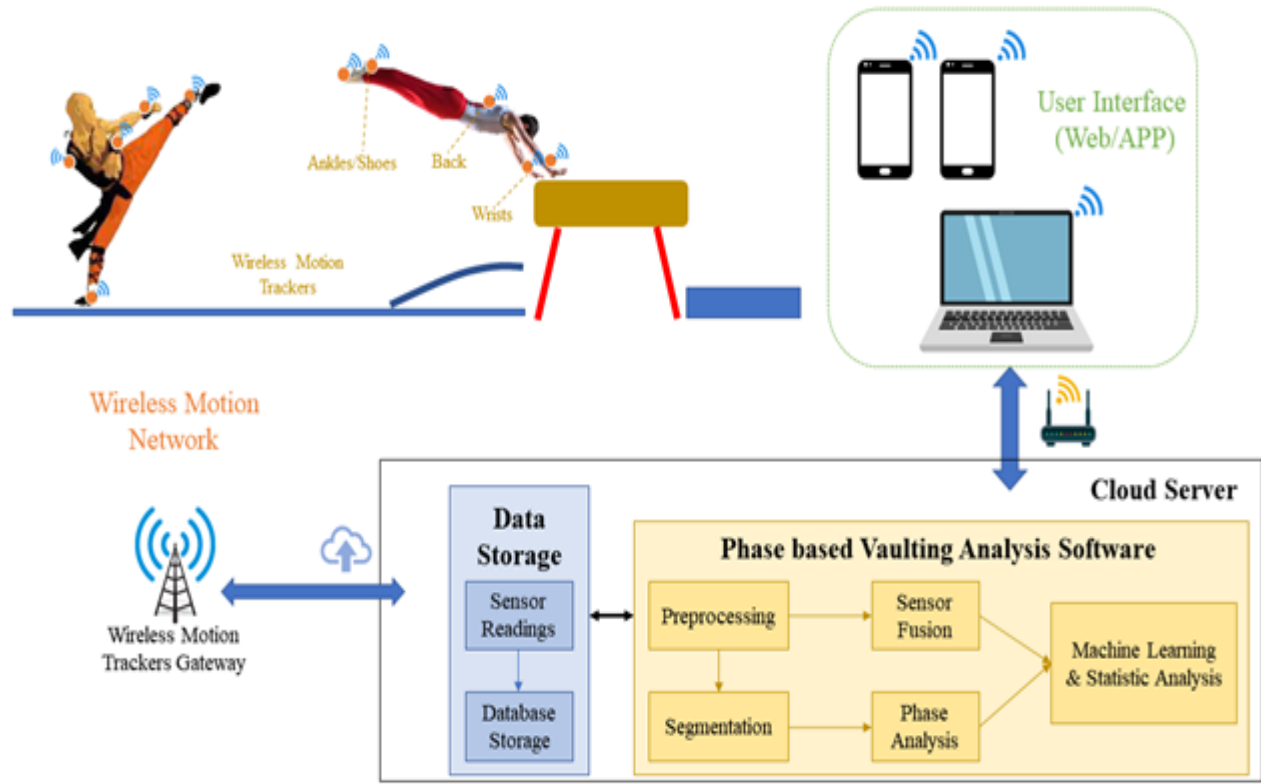
Created by Yichuan Ma | Feb, 2024



Summary of Project Deliverables

1. Capture Karate motion data with markerless system for timely analytic report
2. Develop Karate Computer Vision AI algorithm and user-friendly software package to support 3D model reconstruction from 2D video downloaded from the existing sources

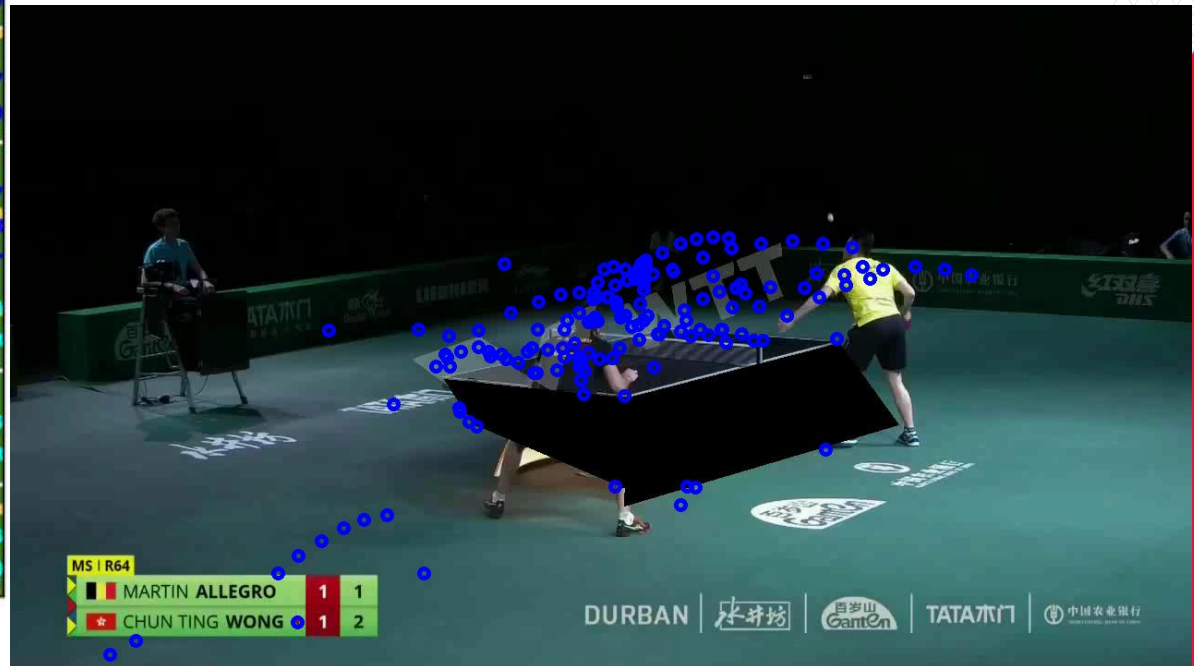
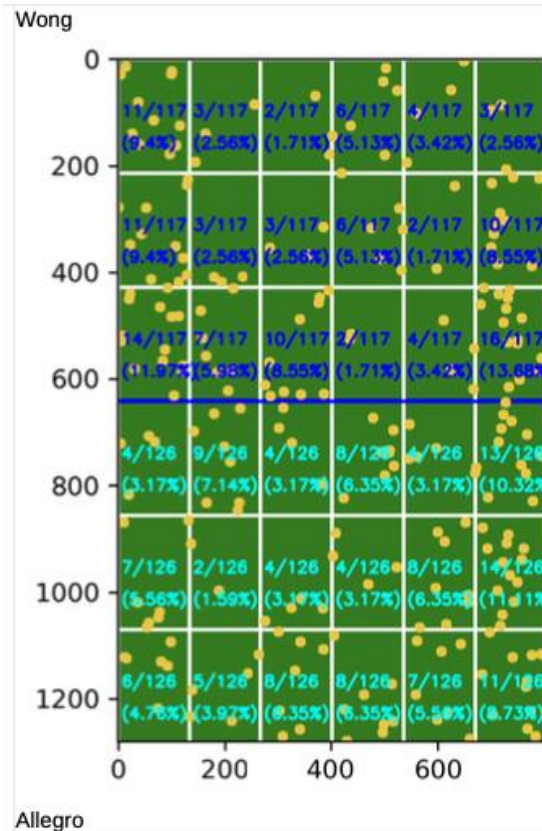
Project 7 - AI Wearable Wireless Micro Motes for Real-Time Motion Analytics of Gymnastics and Wushu Athletes



Summary of Project Deliverables

1. Create a lightweight wearable motion tracking system with AI to monitor and analyse gymnastics vaulting and Wushu motions, giving real-time feedback
2. Automate analysis with AI to reduce manual processing time for analytic reports

Project 10 - Game Analytics and Tactic Planning for Table Tennis



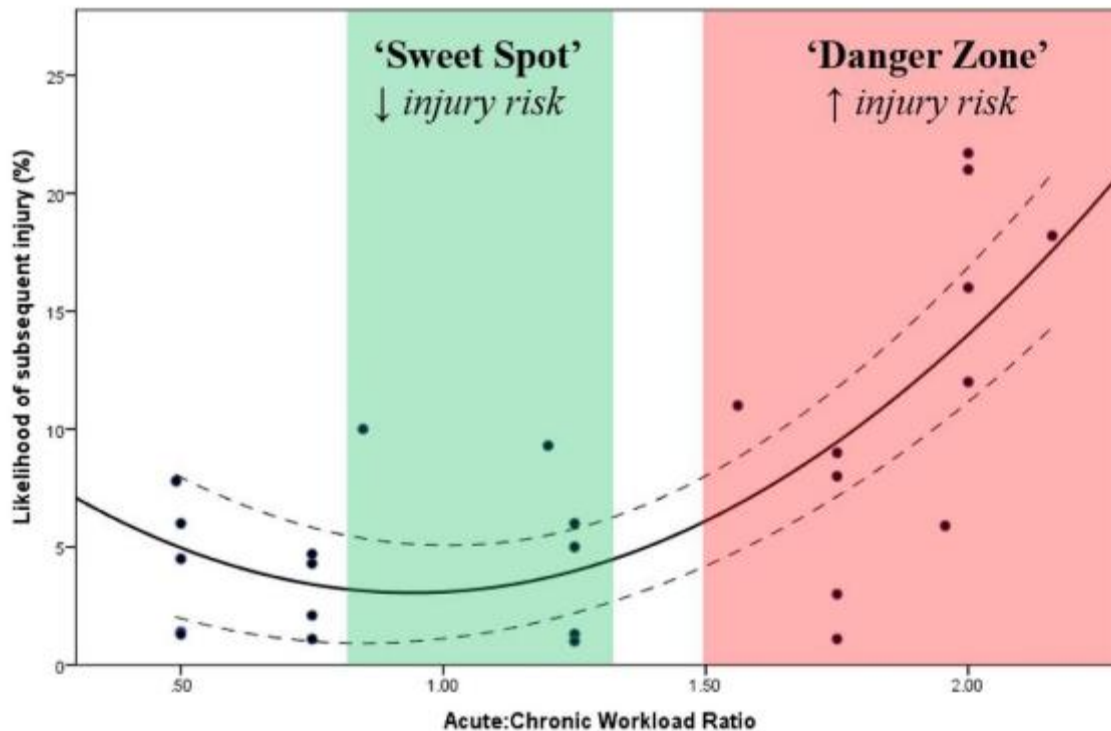
Summary of Project Deliverables

1. Provide timely training feedback and game tactics
2. Develop a one-stop solution for game reviews, tactic analysis and recommendation of Table Tennis using network science, intelligent pattern mining, visualization, and natural language processing

3. On-Training Load Monitoring:

Acute:Chronic Workload Ratio (ACWR)

To monitor an athlete's training load and **the risk of injury**



Tim J Gabbett Br J Sports Med 2016;50:273-280

Example variables to measure loads

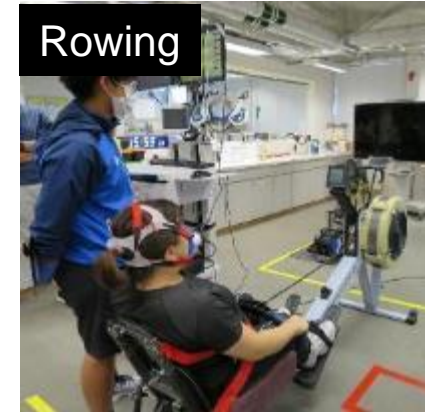
- Training or competition time[13]
- Training or competition frequency[14]
- Type of training or competition[15]
- Time-motion analysis[16]
- Power output, speed, acceleration[17]
- Neuromuscular function (e.g. jump test, isokinetic dynamometry and plyometric push-up)[18]
- Movement repetition counts (e.g. jumps, throws, pitches, serves, bowls)[19]
- Distance (e.g. kilometers run, swam or cycle)[20]
- Acute: chronic workload ratio[21]
[ratio explains 53% of likelihood of subsequent injury]

Benefits of scientific monitoring

- Increased understanding of training responses
- Identification of fatigue and accompanying needs for recovery
- Ensuring therapeutic levels of load to minimise the risk potential

3. On-Training Load Monitoring:

Respiratory Gas Analyser (Cardiopulmonary Exercise Test)



Respiratory gas analysers (MetaMax 3BR2)
Breath-by-breath measurement

Cardiopulmonary Exercise Testing (CPET)
Reflect athlete's performance from exercise gas exchange data
Respiratory exchange ratio (RER)
Measure maximal oxygen uptake (MVO_2)
Determination of anaerobic threshold (AT)

3. On-Training Load Monitoring: Blood Lactate Analyser

Portable lactate
analyser



Lab-based lactate analyser



Monitoring Blood lactate concentration

Indication of training load & intensity
Lactate profile is essential for
performance assessment

Finger tips vs. ear lobes (higher in tips)

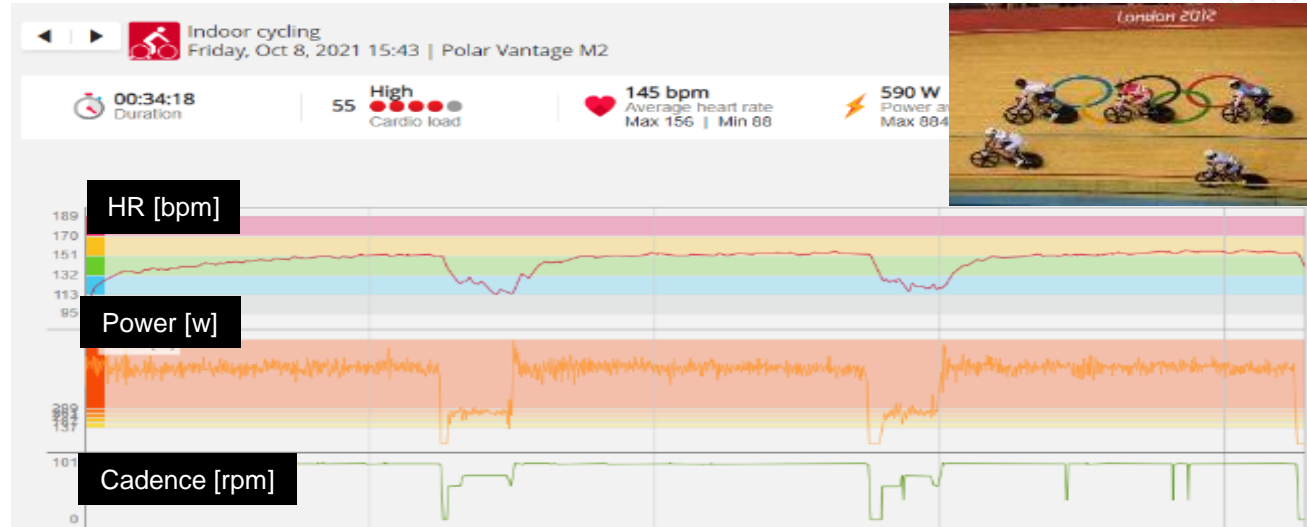


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3. On-Training Load Monitoring:

Heart Rate Monitor

(Polar HR monitoring)



Real-time HR feedback

Allow monitor training zones for optimal zones
Easy-to-use, portable, convenient on field

HR profile of a cycling session (above example)

Synchronise data from power & cadence sensors
Analyse training data across training sessions



Arm band
(Optical sensor)

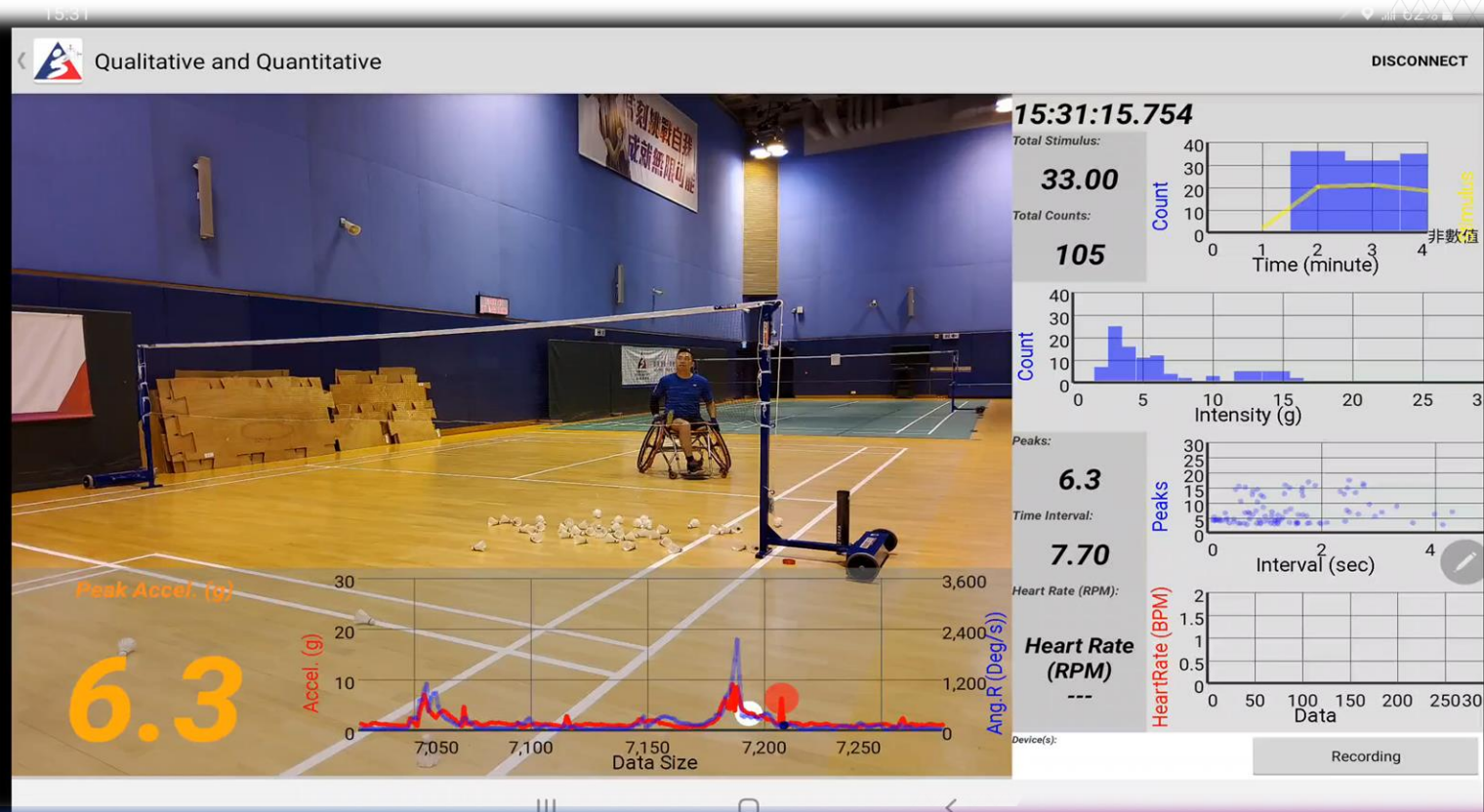
Chest strap
(ECG sensor)

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3. On-Training Load Monitoring:

Portable Device Deployment

- **Smartphone** plays important role in sport technology and especially in remote coaching
- Can video filming, data collection, and communication.
- How they play? How much training load that they have done?



3. On-Training Load Monitoring:



3. On-Training Load Monitoring:

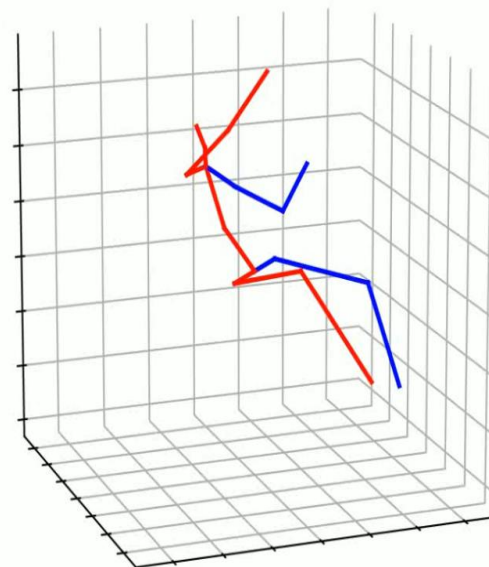
Aerodynamics and Posture Analysis System (Under Development)

All aerodynamics, posture and GPS data integrated in **Single Dashboard** for record and monitoring during field training

Input





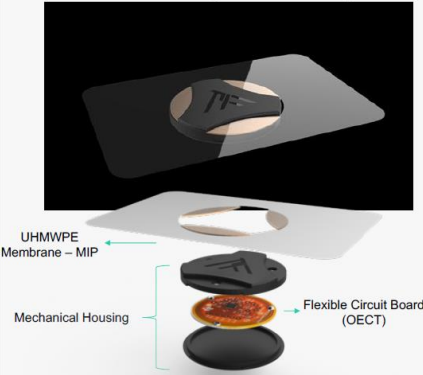


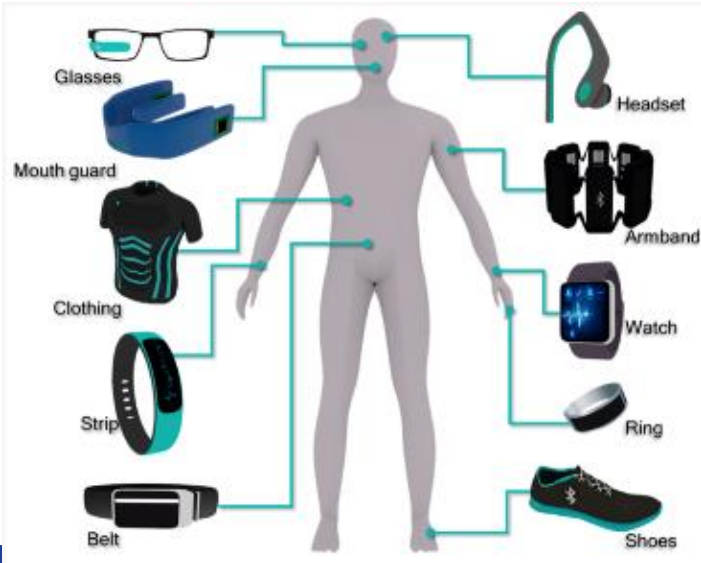
Reconstruction



3. On-Training Load Monitoring: Smart Wearable Monitoring Devices

HR, speed, exertional level, sun exposure, sweating monitoring, calories, ECG, Creatine Kinase monitoring, respiratory rate

<p>Apple Watch HR, HbO2</p> 	<p>SoWatch Blood pressure</p> <p>The first wearable device to track your blood pressure</p> <p>SoWATCH was designed to help you keep an excellent shape. We have integrated many sensors able to track your physiological parameters:</p> <ul style="list-style-type: none"> Systolic & Diastolic blood pressure Heart activity & EKG Fever & Hypothermia Hypoxia : poor blood oxygenation Overtraining & dehydration Sleep troubles <p>Your heart-beat is also an absolute indication of your body state! We have worked with cardiologists and sport doctors to integrate an algorithm able to record the sound of your heart and draw your cardio-respiratory activity as a cardiologist do, send records and measurements to our ergonomics app as you or your physician can display and analyze them when & where ever you want!</p> 	<p>Oura Ring Sleep quality</p> 	<p>Hera Leto Core temp, HbO2</p> 	<p>Point Fit Sweat biomarkers: Cortisol, lactate</p>  <p>UHMWPE Membrane - MIP</p> <p>Mechanical Housing</p> <p>Flexible Circuit Board (OECT)</p>
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Wearables include sensors and software embedded in textiles, watches, patches, earbuds to enhance user's experience

Give real-time physiological & biomechanical data

Allow precise training /recovery plans to mitigate injuries

3. On-Training Load Monitoring:

Integration of Smart Wearables (Human Telemetrics)

All Data integrated in **Single Dashboard** for training and field monitoring

- core body temperature
- skin temperature
- land surface temperature
- hydration status
- sweat rate
- sweat composition
- heartrate and ECG
- cadence
- pace
- foot mechanics



- **Comprehensive understanding of athlete's status & injury risk**
- **Ready for big data analysis for proactive steps to prevent injuries & improve overall health**



4. Effective Recovery Measures:

Oxygen Tent



Cold Water Immersion



Hyperbaric Chamber



Vibration Platform



Localised cryotherapy device



Pulsed Electromagnetic Field (PEMF)



Promote recovery process

Promote tissue healing

Improve muscle metabolism

Control inflammation/pain

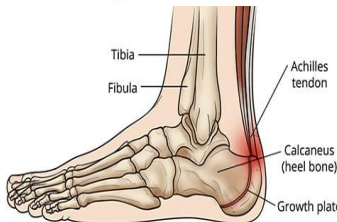
Use of multi-faceted approach for different recovery needs

4. Effective Recovery Measures: Example 1: Ankle Sprain Management

Acute
Ligament
Sprain
Injuries



Chronic
Overuse
Injuries



Promote Healing

1. PEMF



Control Inflammation

- Promote metabolic restoration
- Decrease pain intensity
- Low-Fz PEMF for **Stress fracture & Osteoporosis**
- High-Fz PEMF for muscles and tendons problems (**Achilles/Patellar tendinopathy**)

2. Hyperbaric Chamber (HBO)



Increase nutrients supply

Tissue Maturation & regeneration

- Hyperbaric chamber (HBO) with high pressure and O₂ concentration
- Increase cell recruitment
- Enhance O₂ & blood supply

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4. Effective Recovery Measures:

Example 2: Chronic Overuse Injuries Management



Chronic Overuse Injuries

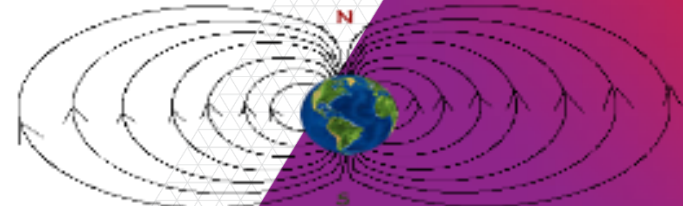
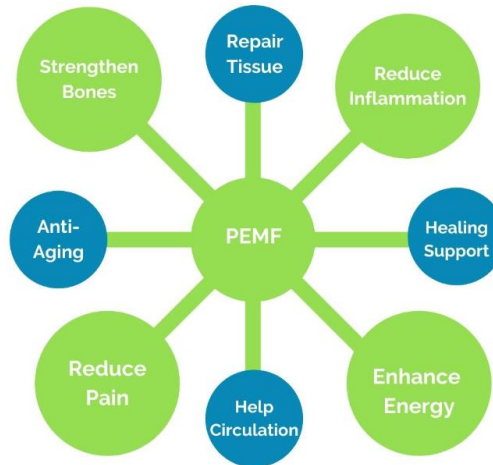
Reduced Symptoms



Control Inflammation

Improve Elastic Properties

- Low-Fz PEMF for **Stress fracture & Osteoporosis**
- High-Fz PEMF for muscles and tendons problems (**Achilles/Patellar tendinopathy**)
- **Decrease pain intensity**
- **Promote metabolic restoration**



4. Effective Recovery Measures:

Example 3: Post-training Muscle Recovery Management



Muscle Recovery

1. PEMF



Muscle Fatigue

- Promote metabolic restoration for muscle relaxation, cellular repair and oxygenation

2. Cryotherapy



Muscle Soreness

- Reduce delayed onset muscle soreness
- Reduce inflammation

3. Vibration Platform



Muscle Hypertrophy

- Force muscles to contract & relax to increase blood flow
- Regain original muscle strength

Some Enhancing Athletic Recovery and Performance with Innovative Techniques and Equipment (easy to self-administer)

Recovery Tools

Athletes employ compression, cold/hot wraps, sleep monitoring, recovery scoring, massage, and near-infrared technology for enhanced recovery and performance.

Hyperice -
Hypervolt 2
Pro



Reathlete Air
Compression
Massager



Viberoll



Infrared
Sauna
Blanket



5. Big Data Analysis:

Common database (Smartabase)



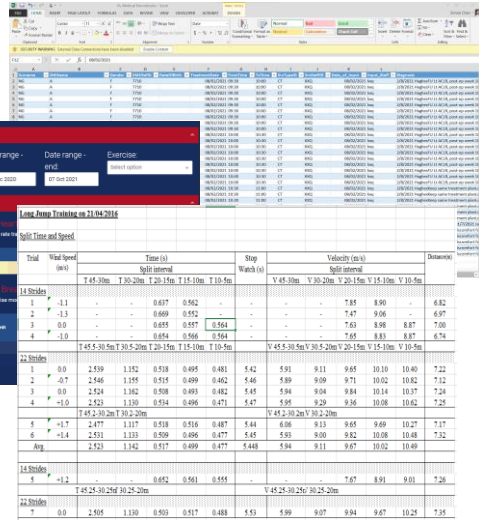
Athletes Input (wellness, fatigue, sleep, HR)
Institute Input (injury/treatment note, test records, biochemistry)



Last 30-day wellness / load trend → **assess injury risk**

5. Big Data Analysis: Common database (under development)

Data / Record



Split Time and Speed	Total	Wind Speed (km/h)	Time (s)	Stop Watch (s)	Velocity (km/h)	Distance
	T 45-30m	T 30-20m	T 20-15m	T 15-10m	T 10-5m	
15 Strokes						
1	-1.1		0.637	0.562		7.85 8.90 6.82
2	-1.3		0.689	0.552		7.47 9.06 6.97
3	0.0		0.655	0.557		7.63 8.96 6.87
4	-1.0		0.614	0.564		7.45 8.93 6.87

Data Transform



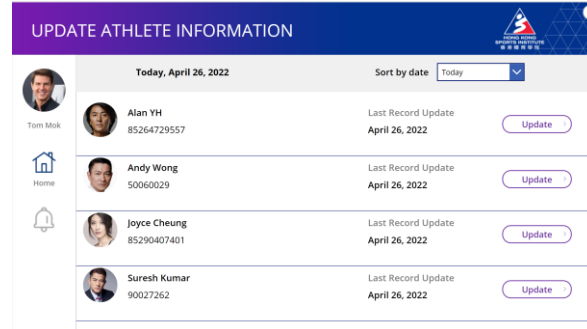
Microsoft Dynamics 365



Data Injection



Data Visualisation

UPDATE ATHLETE INFORMATION

Today, April 26, 2022

Name	ID	Last Record Update	Action
Tom Mok	85264729557	April 26, 2022	Update
Andy Wong	50060029	April 26, 2022	Update
Joyce Cheung	85290407401	April 26, 2022	Update
Suresh Kumar	90027262	April 26, 2022	Update

Mobile Apps

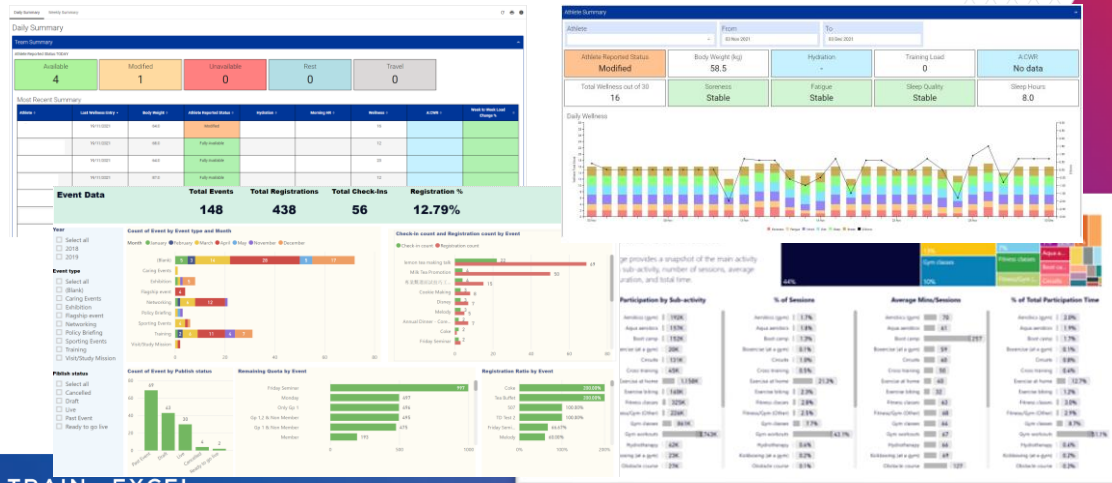


Describe your experience of the following (severity, 5 means very severe)

- Do you experience arm pain caused? 1 2 3 4 5
- Do you experience thigh issues? 1 2 3 4 5
- Do you experience back pain caused? 1 2 3 4 5
- Do you experience pelvic issues? 1 2 3 4 5



Dashboard & Reporting



Daily Summary

Event Data: Total Events 148, Total Registrations 438, Total Check-Ins 56, Registration % 12.79%

Participation by Sub-activity

Sub-activity	% of Sessions	Average Mins/Session	% of Total Participation Time
Swimming (Open)	1.33%	39	1.33%
Swimming (Other)	1.33%	41	1.33%
Rowing (Open)	1.33%	39	1.33%
Rowing (Other)	1.33%	41	1.33%

5. Big Data Analysis: Future: Use of AI for Injury Prediction

Functional

- Muscle strength
- Shoulder ROM
- Kinematics
- Sports performance

Clinical

- Clinical tests
- Injury records
- Treatment notes

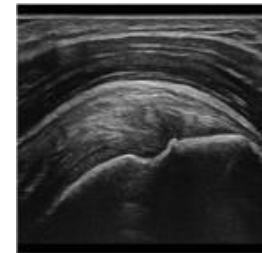
Wearables

- Training load
- Physiology status

AI supervised
machine learning

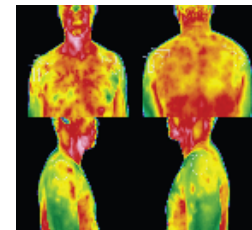


Imaging



Ultrasound imaging

- Tissue composition
- Elastic properties
- Tissue dimensions
- Tissue microcirculation



Infrared Thermography

- Skin temperature



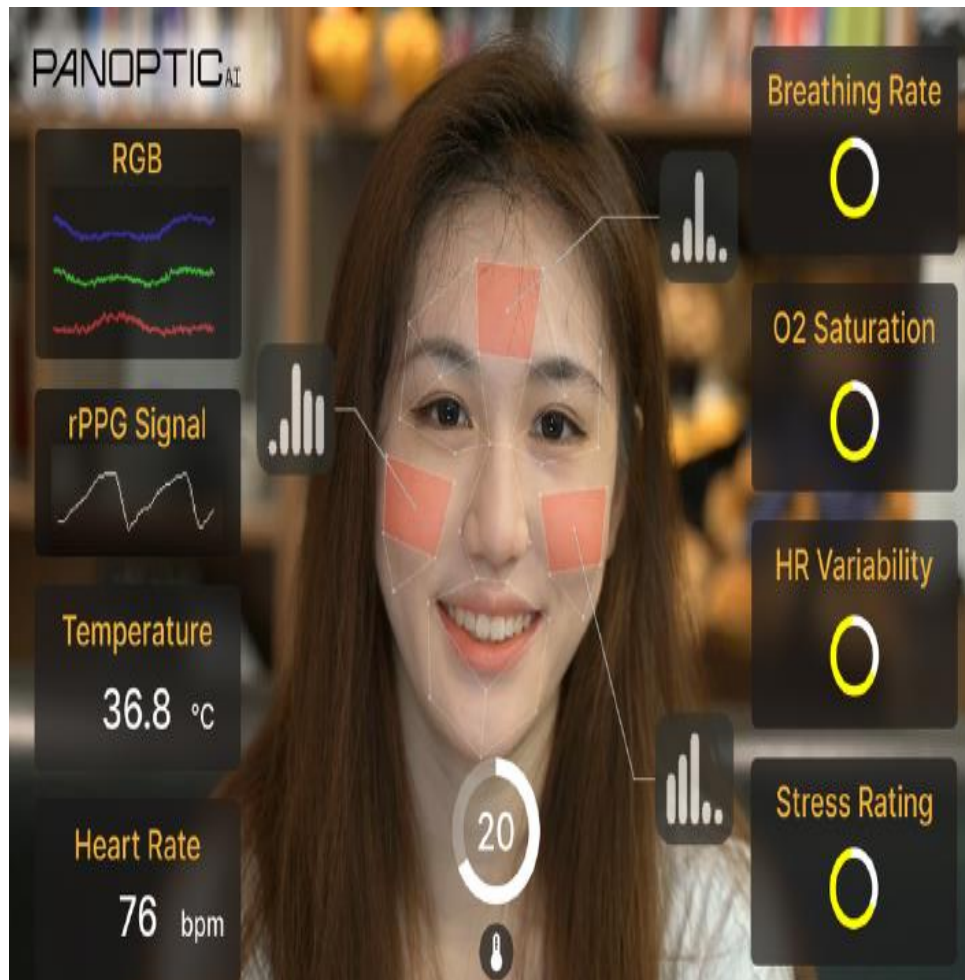
MRI

- Bone & joint structures
- Blood vessel / organs

- New imaging features for **prognosis of shoulder/knee injuries & injury risk prediction**
- Individualised injury monitoring & recovery plan can be achieved for **faster and safer return-to-play**







2. Technical and Risk Assessment:

Advance Computer Vision – Health/Wellness Analysis (Convenient daily record)



Smartphone can to scan the athlete's face

Computer vision algorithms for:

 General Wellness	 Respiration Rate
 Heart rate	 Oxygen Saturation
 Heart rate variability	 Stress Level
 Blood pressure	 Mental Health

- No contact-based devices required
- Not bounded by location or time
- Information for athlete's lifestyle and training

6. Robot Assisted Devices:

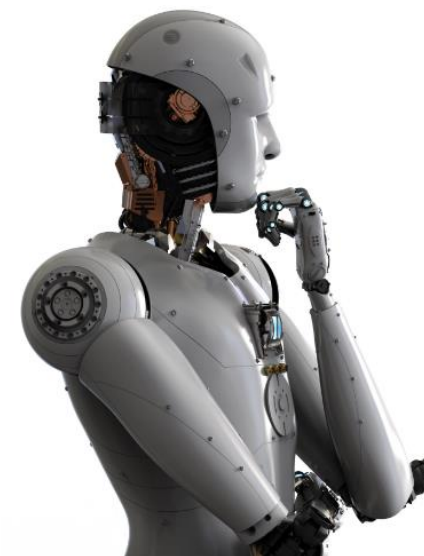
Athletes utilise robots to hone their techniques, assist in strength and conditioning training, and as a training dummy to optimise their performance and prevent injury



Fencing Robot



Massage Robot



**HP-07 ROBOT
+ 80 BALLS
+ CATCH NET**



Automatic Table Tennis Serving Robot

6. Robot Assisted Devices:

Future Mind Table Tennis Training Robot

Features

A **smart table tennis serving robot** that can control ball serving at different speeds, positions and spins for training



6. Robot Assisted Devices: On-Field Training Dummy

Key Function

A **Robotic Sport Training Devices** that is the AI-program, remote controlled, self-righting, padded training dummy.

Features

1. All-terrain
2. Reduce head injuries
3. Reduce player-on-player contact
4. Smart control



6. Robot Assisted Devices: RoboGym

Key Function

A **robotic exoskeleton device** on maintaining muscle strength and bone mass for astronauts who are spending extended periods of time in zero-gravity.

Features

1. Natural
2. Versatile
3. Adjustable
4. Seamless
5. **Safety**



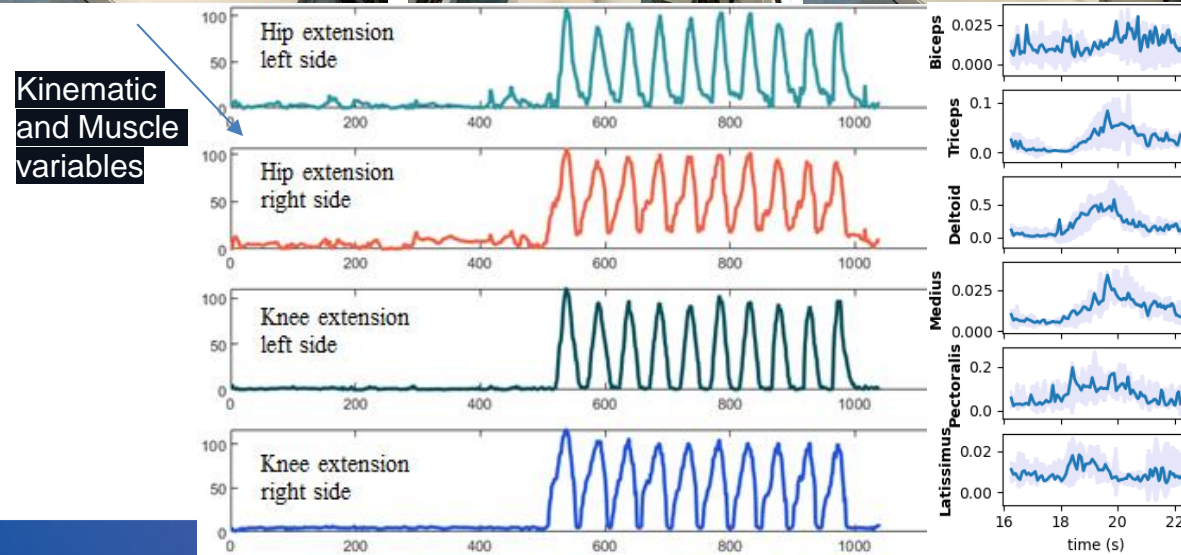
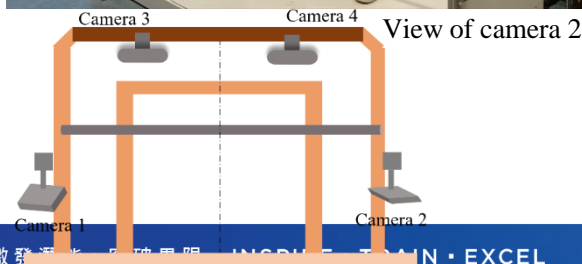
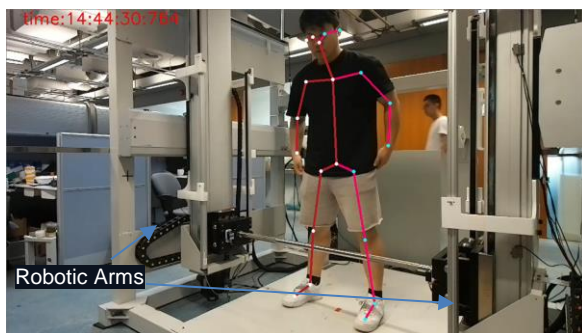
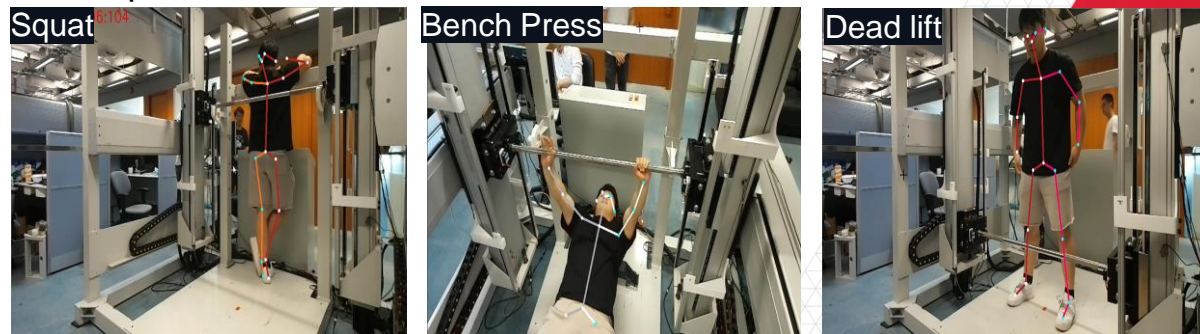
6. Robot Assisted Devices: Strength & Conditioning Training Device (under development):

Key Function

A S&C Robotic Training Devices that integrated with AI sensing system to provide assisted force as similar to spotting during squat and bench press activities.

Features

1. Provide isokinetic, isometric and isotonic, assistive repetition training
2. Smart control and provide assistive forces

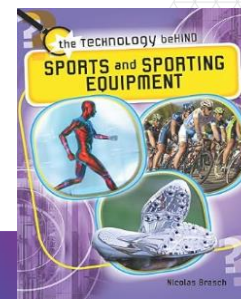
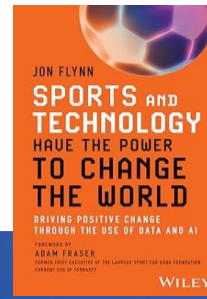
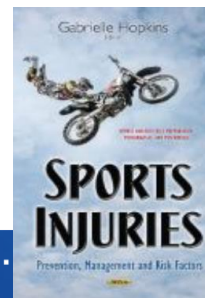
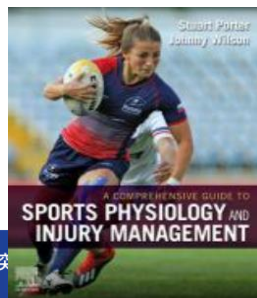


Take Home Messages

- **Technology can be applied to every aspect of elite sports from training, injury recovery, and performance analysis:**
 - Appropriate equipment selection
 - Technical and risk assessment
 - On-training load monitoring
 - Effective recovery measures
 - Big data analysis
 - Robot assisted devices
- **Smart sensor and computer vision application**
 - Increase practicality to support elite training and competition to inform injury risks
- **Accumulate health, training and treatment data**
 - Provide insights into injury prevention and optimising training plans
- **Robot assisted devices**
 - Simulate conditions for safety training and enhance therapeutic modalities
- **Appropriate sports injury prevention can allow athletes to reach their full potential for major Games and improve long-term athletic development**

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Thank you for your listening!