



Modern mHealth Systems

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Computational Biomedicine
Laboratory




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The traditional networked e-health apps




Doctors in Rural

Specialist Hospitals

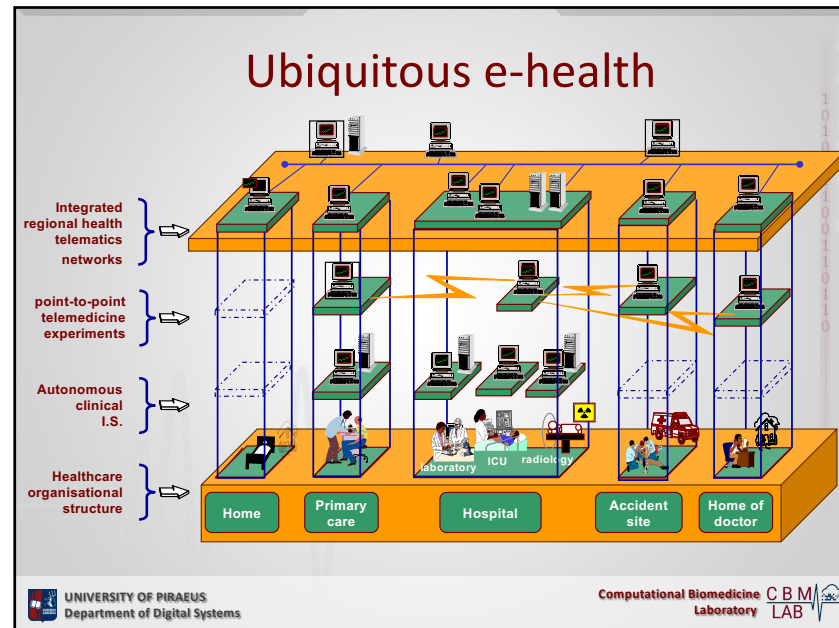


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Features of the modern ehealth systems

- Following the principles of pervasive and ubiquitous computing: Decentralisation, Diversification Connectivity, Simplicity.
- Efficient Processing of Information (Ambient Intelligence): Filtering the unnecessary data
- Context Awareness: Knowing the situation
- Employ state of the art technologies: Internet of Things (IoT), Advanced Sensors
- Bring devices to patients

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Internet of Things and mHealth



Internet of Things technologies and devices contribute to a more connected and intelligent world (Smart *)

New and improved features of **sensors**:

- Advanced sensing and better accuracy
- Enhanced connectivity
- Portability and durability
- Competitive cost

Biosensors (in the past)

Commercial off the self devices

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Towards a holistic approach

- Develop a system or application that supports

Different sensors types

Different vendors

Focused on usability, performance and security

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Telemonitoring Platform

- Utilizing mobile and cloud technologies (micro web services)
- Provided as web and mobile app with the same look and feel

PATIENT MONITORING

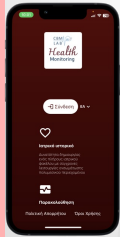
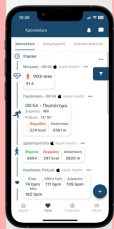
- Client free teleconsultations
- Patient and appointment management features
- Personal Health Record


DATA COLLECTION

- Connection with BLE medical sensors and wearables
- Integration with 3rd party wearable platforms

DATA ANALYTICS

- Dynamic Visualizations and reports
- Integrated questionnaires and data analysis


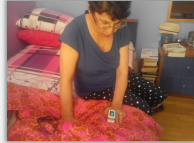


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Study Protocol for the UNCAP H2020 Project

- Each patient was provided with:
 - Android tablet with mobile app pre-installed
 - BLE pulse oximeter
 - BLE blood pressure meter
 - BLE spirometer
- Reminders to enforce measurement and medication schedule
- Regular assessments using well-established questionnaires:
 - Saint George's Respiratory Questionnaire
 - InterRAI
 - User-satisfaction questionnaires

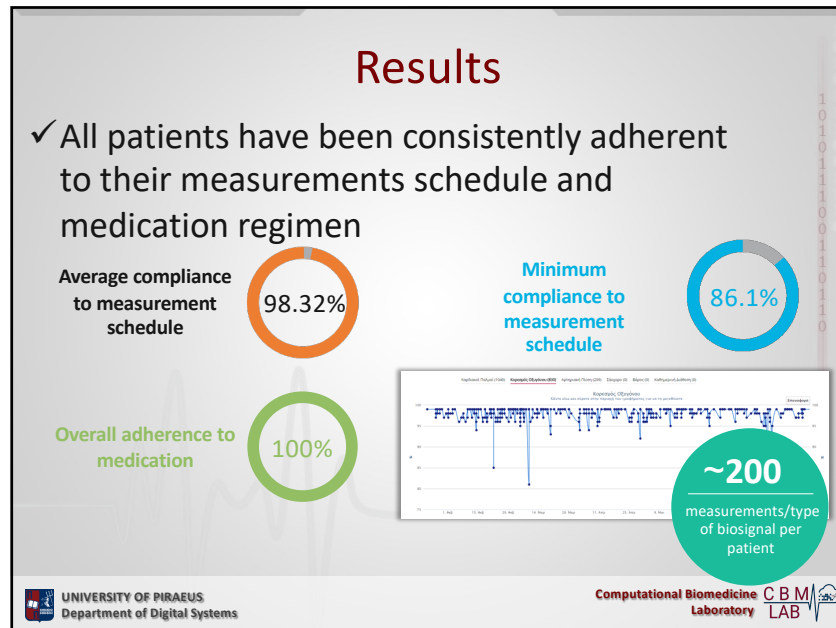




Panagopoulos, C. et al. (2017). Utilizing a Homecare Platform for Remote Monitoring of Patients with Idiopathic Pulmonary Fibrosis. Advances in Experimental Medicine and Biology, vol 989. Springer


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18-NOV-20

Post Covid-19 Monitoring



- ✓ Remote health monitoring
- ✓ Network of support
- ✓ Personal Health Record


Integration with COVID-X Sandbox to enable data-driven services

+

Remote care for patients with mild symptoms

=

Post-discharge monitoring



i-COVID

Intelligent Pervasive Monitoring of COVID-19 Patients using IoT and Cloud

Indicative Tasks

- Predict Medical Research Council (MRC) dyspnoea scale for the next days
- Find important features for prediction

Panagopoulos C, Menychtas A, Jahaj E, Vassiliou AG, Gallos P, Dimopoulou I, Kotanidou A, Maglogiannis I. Intelligent Pervasive Monitoring Solution of COVID-19 Patients. Stud Health Technol Inform. 2022 Jun;295 570-573.

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18-NOV-2021

TECHNICAL INTEGRATION: DATA SCHEMA

Activity Tracking and other Devices: fitbit, WITHINGS, HUAWEI, GARMIN, POLAR, Google Fit, Manufacturer Cloud.

i-COVID App: Heart rate, SpO₂, and other data.

i-COVID Platform: Questionnaires and other manual entry data.

Challenges:

- Granularity
- Streaming vs. batch data
- Data format
- Push vs. Pull communication
- Static vs. Dynamic properties
- Semantics

Final COVID-X schemas:

- Include flat format
- Represent streams as single measurements
- Adopt the COVID-X guidelines for the format of certain parameters

Support of multiple data types:

- Measurements
- Sleep
- Steps
- Workouts
- Questionnaires
- Medical Forms

Symptoms tracked over 13 days: Insomnia, Low grade fever, Headache, Anorexia, Sore throat, Cough, Nausea, Arthralgia/myalgia, Nasal congestion, Rhinorrhea, Fever, Fatigue, Loss of taste/smell.

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18-NOV-2021

Post Covid-19 Monitoring

Predicting day 5:

Feature	Importance
Diabetes	0.12
Days from last dose	0.11
Gender	0.10
Age	0.09
Smoking	0.08
Asthma	0.07
Ill before	0.06
Drugs	0.05
Coronary	0.04
Pfizer-BioNTech (COMIRNATY)	0.03
Moderna	0.02
Johnson and Johnson	0.01
AstraZeneca (Vaxzevria)	0.01
Hyperlipidemia	0.01
Heart rate	0.01
COPD	0.01
Hypertension	0.01
Dosage	0.01
Body temperature	0.01
Diastolic pressure	0.01
Systolic pressure	0.01
Weight	0.01

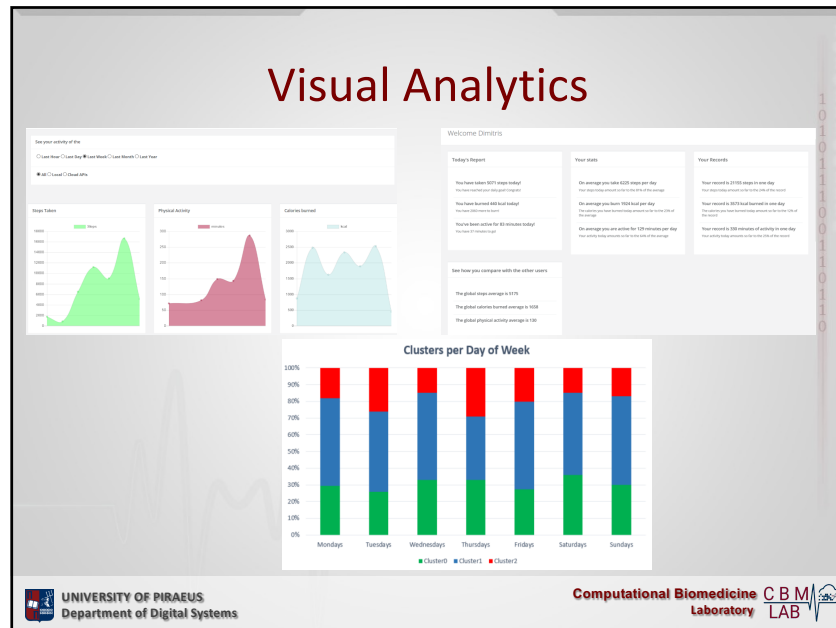
The importance score of feature variables for predicting the MRC grade in the coming days

Importance score of variables with respect to days for prediction

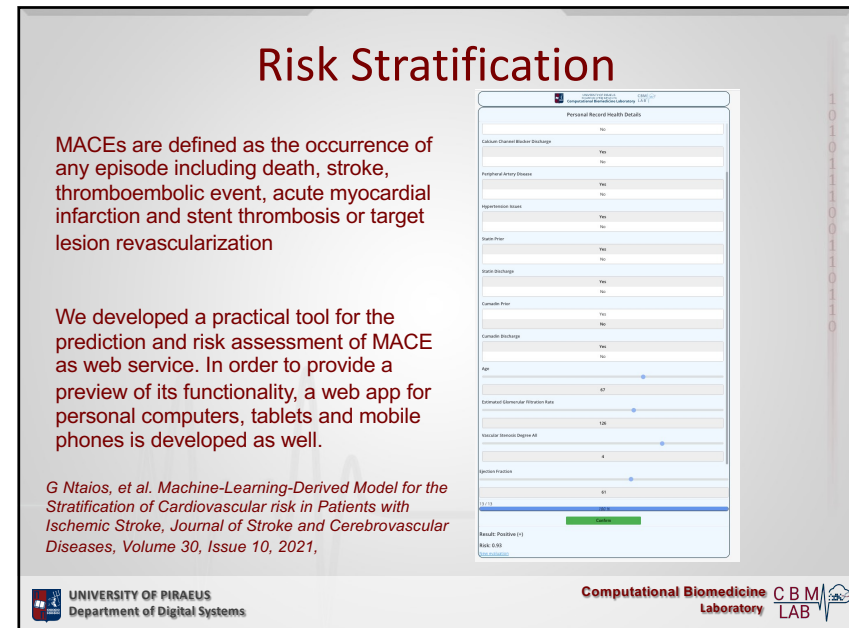
Legend for Feature Importance over Days: Weight, Systolic pressure, Diastolic pressure, Body temperature, Hypertension, Dosage, COPD, Heart rate, Hyperlipidemia, AstraZeneca (Vaxzevria), Johnson and Johnson, Moderna, Pfizer-BioNTech (COMIRNATY), Coronary, Drugs, Ill before, Asthma, Smoking, Age, Gender, Days from last dose, Diabetes.

Tziomaka, M.; Kallipolitis, A.; Menyctas, A.; Gallos, P.; Panagopoulos, C.; Vassiliou, A.G.; Jahaj, E.; Dimopoulou, I.; Kotanidou, A.; Maglogiannis, I. Extracting Interpretable Knowledge from the Remote Monitoring of COVID-19 Patients. Mach. Learn. Knowl. Extr. 2024, 6, 1323-1342.

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Emotion Analysis in Practice

Remote Camera Emotion
 Amaze = 0.0256
 Disgust = 0.0000
 Fear = 0.0104
 Happy = 0.0294
 Neutral = 0.2966
 Sad = 0.0013
 Surprise = 0.6379
 31 ms (res. time)
 372 ms (average)

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Monitoring and Relapse Prevention in Patients with Psychotic Disorders

e-Prevention

Management & Reporting Tools: User Management, Data Management, Cloud Platform, Reporting, ML Data Analytics, Video Communication, Notifications, Visualizations, Signal Processing.

User Apps: Patients (Smartwatch, Smartphone)

Doctor Apps: Doctors (Stethoscope, Monitor)

Operation Apps: Admins & Data Analysts (Laptop, Document)

Data Pipeline: Data Collection (Smartwatch, Smartphone, Footprints) → Upload → Cloud Storage → Data Analysis → Web Portal → Medical Intervention

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Data Collected

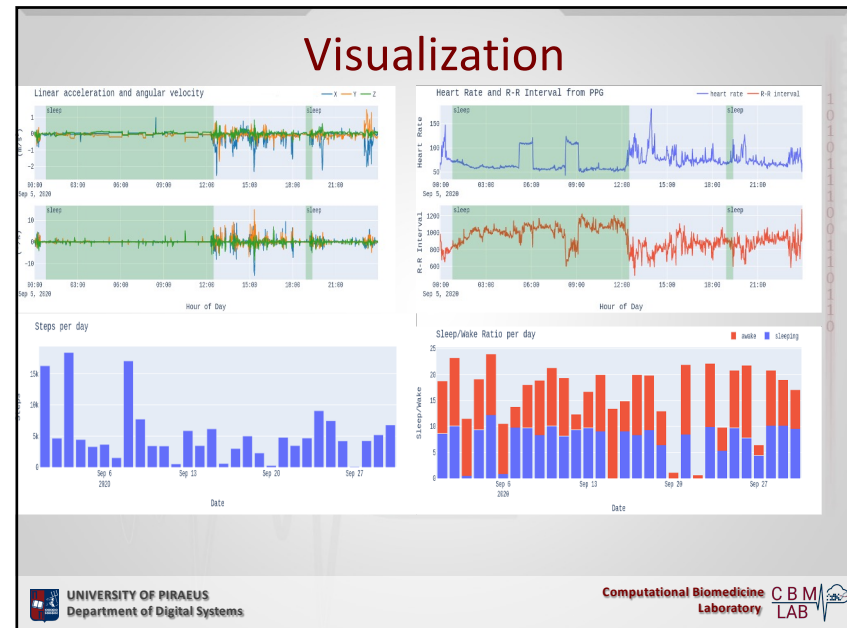
Sensor	Data	Measurement Unit	Frequency Sampling
Accelerometer	Linear Acceleration (3-axis)	m/s ²	20 Hz
Gyroscope	Angular Acceleration (3-axis)	degrees/s ²	20 Hz
Heart Rate	Heart Rate Variability RR-Intervals	beats/min seconds	5 Hz
Step Counter	Steps and Total distance	steps/min	Total number per minute
Sleep	Sleeping schedule	min	

1 0 1 0 1 1 0 0 1 1 0 1 1 0 1 1 0

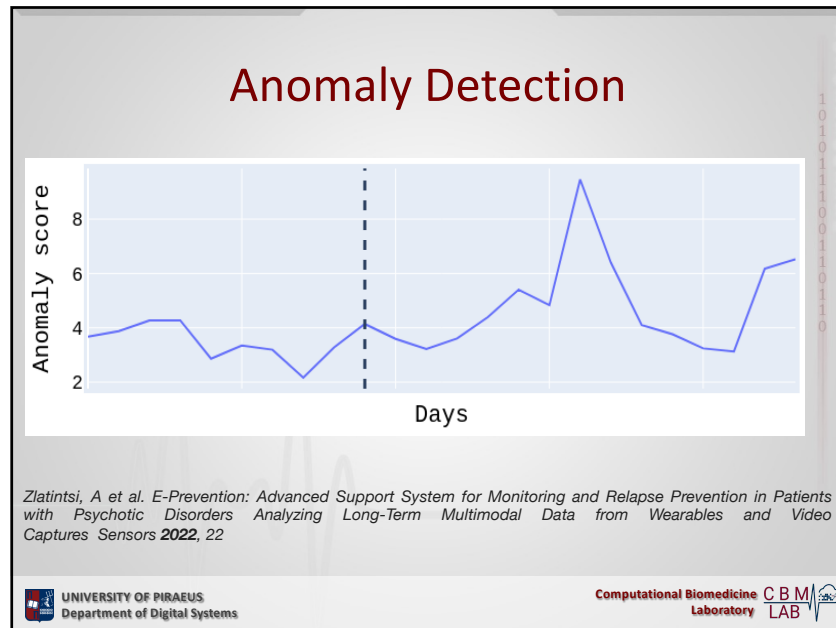
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Facial Expression Analysis

- Aiming to extract useful correlations between PANSS questionnaires and video facial expressions
- 10 corresponding PANSS items have been dictated by specialized personnel, due to their correlation with facial expressions:
 - Excitement
 - Absent
 - Hostility
 - Minimal
 - Anxiety
 - Mild
 - Poor Impulse
 - Moderate
 - Motor Retardation
 - Moderate-severe
 - Depression
 - Severe
 - Tension
 - Extreme
 - Blunted Affect
 - Poor Rapport
 - Lack of Spontaneity, Flow of Conversation

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Classification results

PANSS Items	BOVW2BOVW2						EfficientNet to BOVW					
	RF		XGB		SVM		RF		XGB		SVM	
Depression (6c)	0.49	0.82	0.6	0.85	0.30	0.68	0.47	0.64	0.53	0.64	0.30	0.75
Anxiety (5c)	0.44	0.65	0.37	0.69	0.33	0.84	0.26	0.77	0.36	0.77	0.29	0.85
Tension (4c)	0.70	0.89	0.68	0.85	0.56	0.62	0.54	0.77	0.61	0.85	0.46	0.81
Poor Rapport (4c)	0.44	0.86	0.49	0.90	0.34	0.68	0.41	0.86	0.55	0.82	0.34	0.57
Poor Impulse Control (3c)	0.72	1	0.71	0.79	0.39	1	0.43	0.96	0.66	0.82	0.37	0.96
Motor Retardation (4c)	0.40	0.75	0.60	0.82	0.36	0.75	0.41	0.82	0.40	0.79	0.32	0.79
Excitement (4c)	0.58	0.78	0.61	0.82	0.42	0.78	0.49	0.85	0.47	0.85	0.41	0.67
Hostility (3c)	0.72	0.96	0.68	0.93	0.42	0.78	0.42	1	0.60	0.89	0.49	0.79
Blunted Affect (5c)	0.58	0.68	0.55	0.64	0.34	0.64	0.34	0.64	0.47	0.68	0.30	0.64
Lack of Spontaneity (5c)	0.49	0.64	0.65	0.79	0.40	0.75	0.49	0.64	0.26	0.68	0.43	0.75

Tziomaka, M., Kallipolitis, A., Tsanakas, P., Maglogiannis, I. (2021). Evaluating Mental Patients Utilizing Video Analysis of Facial Expressions. In Artificial Intelligence Applications and Innovations. AIAI 2021 IFIP WG 12.5 International Workshops. AIAI 2021. IFIP Advances in Information and Communication Technology, vol 628. Springer



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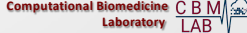
Recommender Systems

- Virtual Coaches
 - Motivate users for healthy habits
 - Based on personal information (age, location, physical condition, medical history, chronic diseases, etc.) and biosignals data
 - Collaborative Filtering to find similarities between users
 - Content-based Filtering to find a related plan based on the user data

Erdeniz, S.P., Menychtas, A., Maglogiannis, I. et al. Recommender systems for IoT enabled quantified-self applications. Evolving Systems 11, 291–304 (2020).



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Profiles of Users								
profile	age	Demographics			chronic diseases	Devices		BPM
		gender	location	location		oximeter	wristband	
user-1	young	male	urban	asthma	✓	✓	-	
user-2	middle	female	suburban	diabetics	-	-	✓	
user-3	elder	male	suburban	diabetics	-	✓	-	
active user	young	female	urban	asthma	-	✓	-	

Table 1. Profiles of users are stored in the online server of the recommender engine in anonymous mode (without their names, addresses, etc.).

Medical data of a patient and possible activity plans			
	systolic blood pressure (mm Hg)	heart-rate (bpm)	weight (kg)
targets of plan-1	↓	↓	↓
targets of plan-2	↓	↔	↔
targets of plan-3	↔	↔	↔
targets of plan-4	↔	↔	↑
targets of patient-1	120.00 (↓)	70.00 (↓)	80.00 (↓)
actuals of patient-1	142.00	91.00	108.00

Table 2. Actual and expected (targets) measurements of patient-1. The targets of the available activity plans are also represented. Arrows denote increase(↑)/decrease(↓)/stay(↔) targets of a plan. For instance, plan-2 is targeting to decrease the blood pressure and weight. Therefore, plan-2 includes activities which can decrease these two parameters.

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Gamification and Coaching

- For user's motivation a gamification leaderboard and comparison graphs were developed.
- User's performance comparison graphs.
- Using the figure graphs, users can be informed regarding their performance for several factors.
- Their performance comparison with other similar (by gender and-or by age range) users can lead them to adjust their behaviours in order to "win the game" and fulfil their targets.
- Based on the user's rank on the leaderboard, the elders can receive through the mobile application personalised motivation messages to continue the suggested by their care plan activities.

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The screenshot displays a mobile application interface for health monitoring. It features several panels: a main dashboard with various health indicators, a 'Medilud...' section with gamified challenges (e.g., 'Στόχος ημερήσιων βήματων', 'Μεταγενεατικό Σάκχαρο'), and a risk assessment tool for cardiovascular diseases. The interface uses colorful icons and progress bars to engage users.

Pardos A, Menychtas A, Gallos P, Panagopoulos C, Maglogiannis I. Gamification and Coaching in Remote Monitoring and Care Platforms. *Studies in Health Technology and Informatics*. 2022

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Integrating AR and IoT Services

The diagram illustrates the integration of AR and IoT services. It shows a hand wearing a smartwatch, a smartphone displaying AR content (a dog and a house), and a virtual environment with IoT devices (a bed, a desk, and a chair). The AR content is overlaid on the real-world environment. The diagram also includes logos for ARCore, Android, and Wear OS by Google.

Koulouris, D.; Menychtas, A.; Maglogiannis, I. An IoT-Enabled Platform for the Assessment of Physical and Mental Activities Utilizing Augmented Reality Exergaming. *Sensors* 2022, 22, 3181

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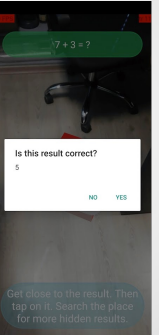
Indoor Exergaming



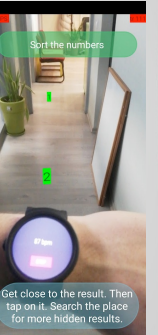
(a)



(b)




(c)




(d)

Get close to the result. Then tap on it. Search the place for more hidden results.



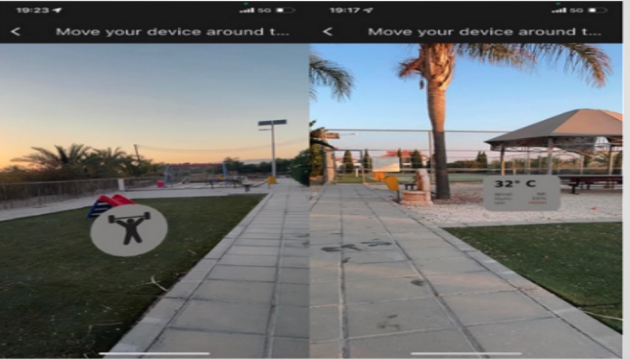
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Integrating AR and IoT Services

Location based information





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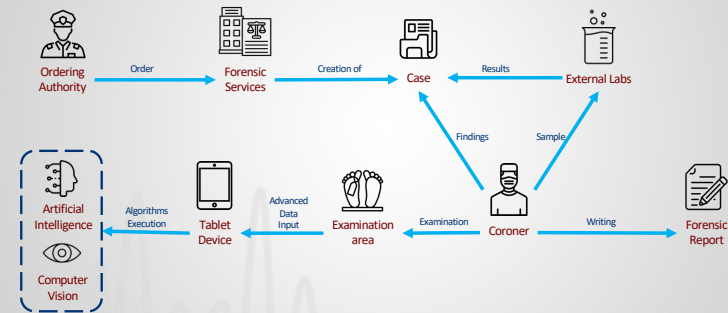
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Information System for Supporting the Greek State Medical Forensic Services

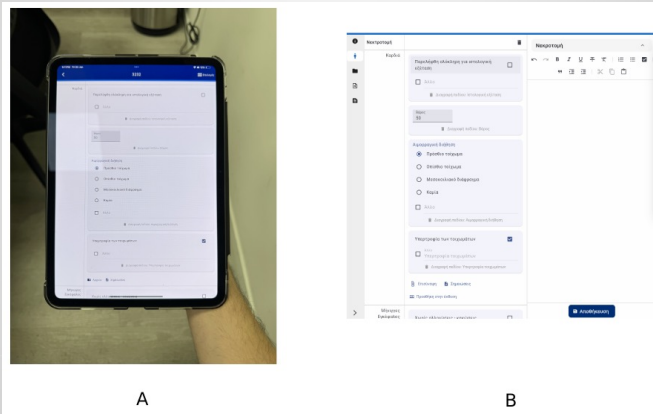
- Use of tablet devices at the examination area**
 - Capture photos and videos
 - Data entry
 - Quick access to related data
- Execution of AI algorithms for**
 - Case feature extraction
 - Case confirmation
 - Text generation for the Forensic Report
- Examination of Computer Vision methods for**
 - Image segmentation
 - Point of interest identification of images and videos
 - Identification, analysis and quantification of findings



System Architecture

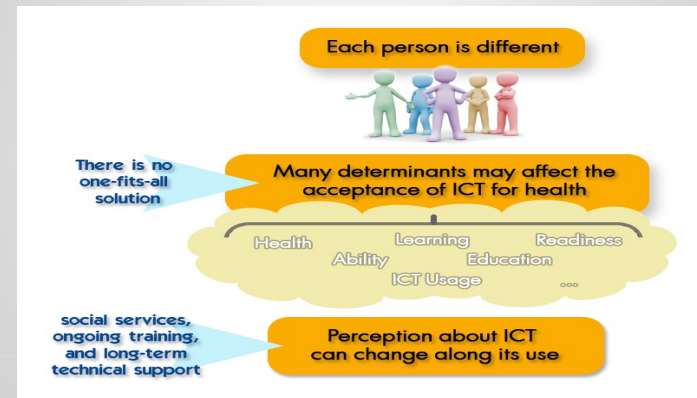


The system in Practice



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Challenges: Personalization



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Challenges: Better Intelligence

- Edge Computing should be reinvented
 - have the right edge devices that can perform analytics locally when needed and send selective data up to the cloud for deeper analytics.
- Deep NNs and GPUs may invade the world of IoT and Artificial Intelligence
 - IoT, Machine and Deep Learning, Artificial Intelligence and other Big Data applications, GPUs have emerged as the leading processing technology for data analytics.

Challenge: Ethics

- New Guidelines
 - Privacy by Design
 - Right to Access
 - Right to be Forgotten
 - Breach Notification
 - Data Sharing and Consent Management
 - Transparency, trustworthiness, interpretability
 - Keeping Humans in the loop

We are living the Age of Scale

DIGITAL HEALTH
Digital Health's Global Evolution : 2003 – 2025 (And Beyond)

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The Computational Biomedicine Research Lab, within the Department of Digital Systems in University of Piraeus consists of faculty members with PhDs in the area of biomedical informatics and machine learning, who supervise postgraduate research work of highly qualified graduate engineers. The group has great expertise in developing e-health applications and in medical data processing. A number of apps and tools have been developed by the group allowing proper acquisition, coding and transmission of medical data, while also serving as diagnostic aids. Apart from the aforementioned tools, the group has established a repository of medical data consisting mainly of medical images and biosignals of various modalities.

Big Data Health Analytics

Bioinformatics

Home Care and Patient Monitoring

The Laboratory serves the following educational and research subjects:

- Biomedical Engineering and Technology
- Biological Processing
- Analysis of Biomedical Images
- Pattern Recognition in Medical Data
- Biosensors Technologies
- Wireless Sensor Networks and Internet of Things
- Environments for Independent Living
- Living Labs
- Bioinformatics

Activity Recognition

Emotion Analysis and Affective Computing

Dental Image Analysis

Digital Microscopy Image Analysis

Fall Detection

R&D PROJECTS (Selection)

- PROMISE – Personalization of melanoma therapeutic management through the fusion of systems biology and intelligent data mining methodologies – Greece-China Collaboration
- TRANSITION – Translating the diagnostic complexity of melanoma into rational therapeutic stratification
- MEGALOCUS – Personalized Medical Care through Serious Games and Gamification
- e4LICO – “e-Laboratory for Interdisciplinary Collaborative Research in Data Mining and Data-Intensive Sciences European Commission (IST-2007)
- CrowdHEALTH – Collective wisdom driving public health policies (H2020)

Digital Democracy Image Analysis

AS Initialization

3D Medical Image Segmentation

Mobile Applications

Wearables and Assistive Living

Heart Sound Analysis

On-line Collaboration Tools

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