



Research Consortium in Speckled Computing

# Sonification of Gestures using SpeckNets

Vangelis Lympouridis

Edinburgh University

Vangelis@Lympouridis.gr



Doctoral Award Holder from  
Arts & Humanities  
Research Council



NAPIER UNIVERSITY  
EDINBURGH



UNIVERSITY OF  
STRATHCLYDE

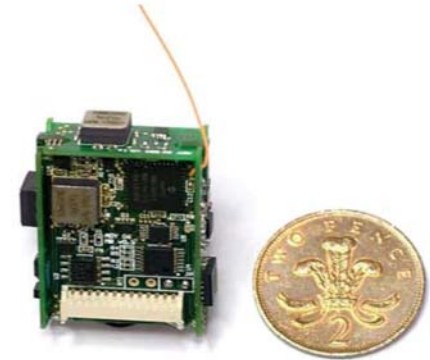
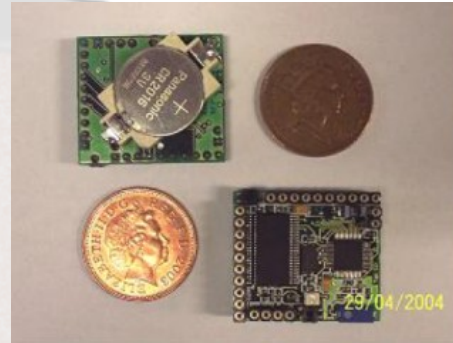


University  
of  
St Andrews

# Description of Specks and the Orient-2 devices

There are two main devices

- **Prospeckz**
- **Orient2**



Orient2 Speck

**Specks** are devices that can form **Programmable** wireless networks able to sense, process and deliver computation in real-time (sensor networks)

The **Orient-2** devices are based on Specks equipped with

- 16-bit microprocessor, 250 Kbps radio, 3-axis accelerometer, two 2-axis magnetometers and three rate gyroscopes.

These devices are wireless **INU** (Inertial Navigation Units), that can be understood as **accurate digital compasses**.

# Data and Wireless capabilities (Orient2)

## DATA

- **Raw (but calibrated)** data, 9 values.  
(Acc. ,Mag. ,Gyros)
- **Quaternion data**, 4-dimensional complex numbers (Scalar and 3xyz coordinates)
- The data are **filtered calibrated and processed on the device.**
- There is also an **onboard memory** for capturing data
- Upper body model  $\rightarrow$  5sensors  $\times$  13values  $\times$  64 samples/sec = 4160 values per sec.

## WIRELESS

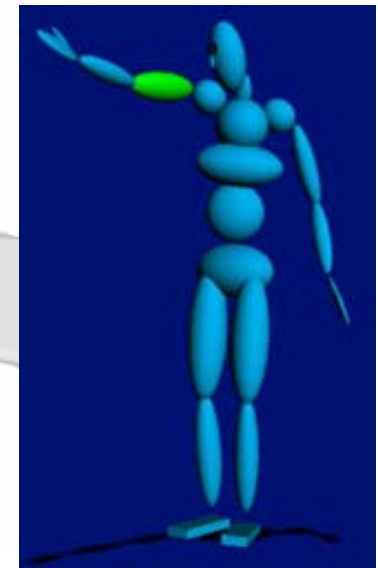
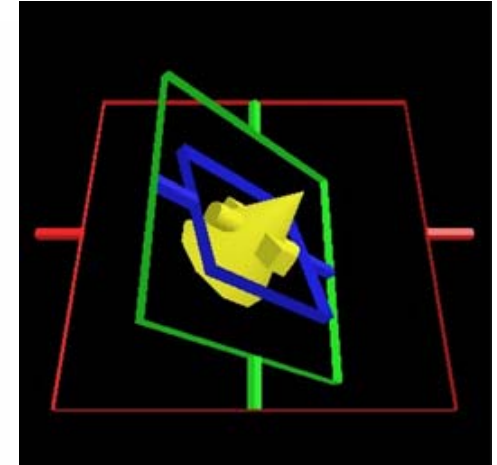
- Eliminate the effect of **signal absorption** from the body with the use of **~900Mhz** freq. instead of **2.4Ghz** (microwave).
- Up to **20m**. Signal **range**.
- **TDMA** and **orientation estimation** result a 8ms frame sequence (max.125 frames per sec.) for an upper body model.

# Conceptual Approach

- **Virtual Musician** for a performer-dancer (Dancers have more accurate movements but the system needs an extra layer of a strong composition concept)
- **Virtual Instrument** for a musician (the musician defines the framework of the composition live, but motion analysis has to be carefully filtered, classified and mapped to the sound modules)
- Mapping of audience movement and orientation, in a **Interactive Public Art** concept (That involves more restrictions and abstractions). Several **control interfaces** can be easily constructed as the motion and orientation **data** are very **fast and accurate**.
- The main benefit of using **Orient2** specks instead of cameras is basically the **independence** of the system **from environmental conditions**, such as light.
- **Camera** based systems conceptually arise from “**vision**” while the **Orient-2** system arise from “**motion**”.
- **Other sensor based systems** are capable of sensing several qualities of motion such as acceleration but they can not provide **3-D localization**, accurate orientation data, and tracking.

# Body model and Quaternion Maths

- **Quaternion** maths are commonly used in virtual representations as they bypass the limitations of **Euler angles** and simplify 3-D vector rotations of complex systems (instead of 3-D Matrix Rotations)
- **Depending** on the **conceptual approach**, quaternion analysis and synthesis can address the desired data of motion analysis
- Quaternion values are used to **rotate 3-D vectors** of a rigid model.
- **The rigid model** can either have a **relative** or a **fixed** position in the **3-D space**. (conceptual decision)
- **16 Sensors** can model a full human (rigid) **body**.



# Meta Data and Classification

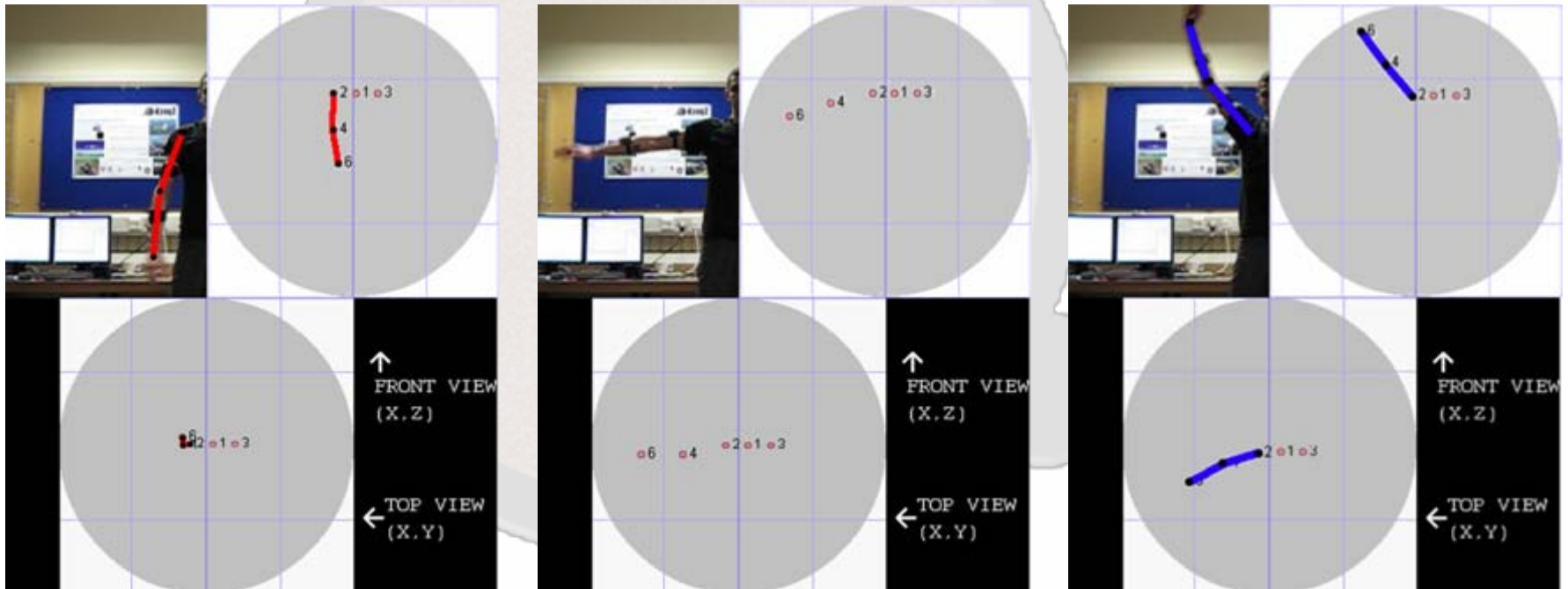
- **Meta Data.** as **linear distance** between hands, or **triangulation** measurements from an external point, but also acceleration and velocity can be easily extracted from the XYZ coordinates of the model.
- **Angles** from the **limbs** can also be easily extracted.
- [\(video\)](#)



- The current conceptual approach involves the construction of a **3D-Grid** from the centre of the body model. **Classification** for the **position** of the hands on the grid is performed with the **Mahalanobis** Algorithm.
- The algorithm can provide the **ID number** of the cell and the **relative distance** of its centre from the floating point (hand)
- **Each** additional **Cube** from the 3D-Grid can be perceived as a **little box** where **information can be stored and recalled** with the help of a Matrix (FTM-mat)
- Fundamental frequencies, Filtering data, SDIF, or any other data can be stored.

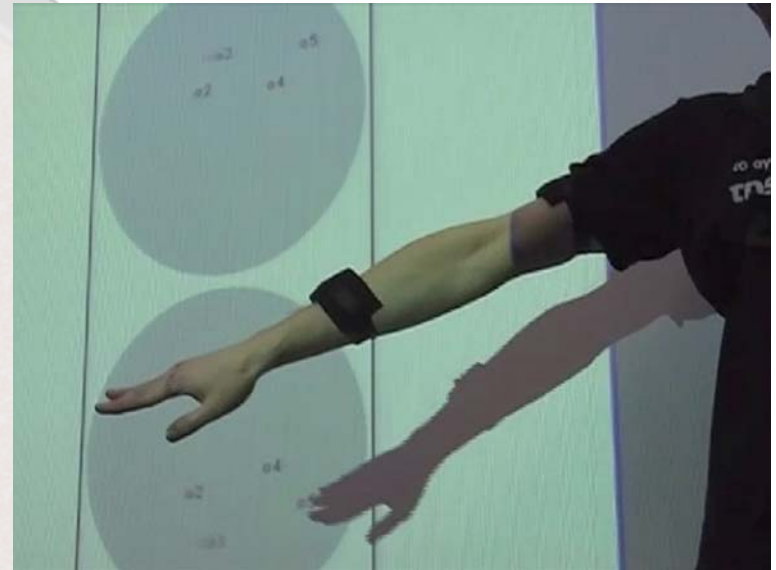
# Current Body Model Testing

- [Video File](#)



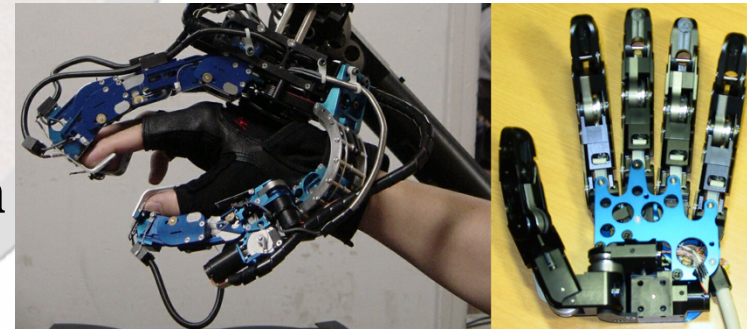
# Synthesis and Sonification

- **Until recently** the tracking system connected to **MaxMsp** needed more than **80%** of a 2.4Ghz **processor** just to model the upper body of a performer, due to the use of an **external python library** for working with **quaternion** maths.
- The **problem** was **solved** with the use of **FTM** library for MaxMsp (**IRCAM**) and the processing power that is now needed is **10%**.
- Because of this, now bypassed, limitation the system has been tested so far with very **limited synthesis concepts and tools**, such as **FM synthesis** and **Scanned** synthesis. ([video](#))
- More advanced and with higher complexity **composition and sonification methods** are yet to be explored and extensively tested.
- Depending on each **concept**, either arise from performance or musical composition, the proposed **system** has to be **flexible** to address specific needs and respond with **accuracy**.

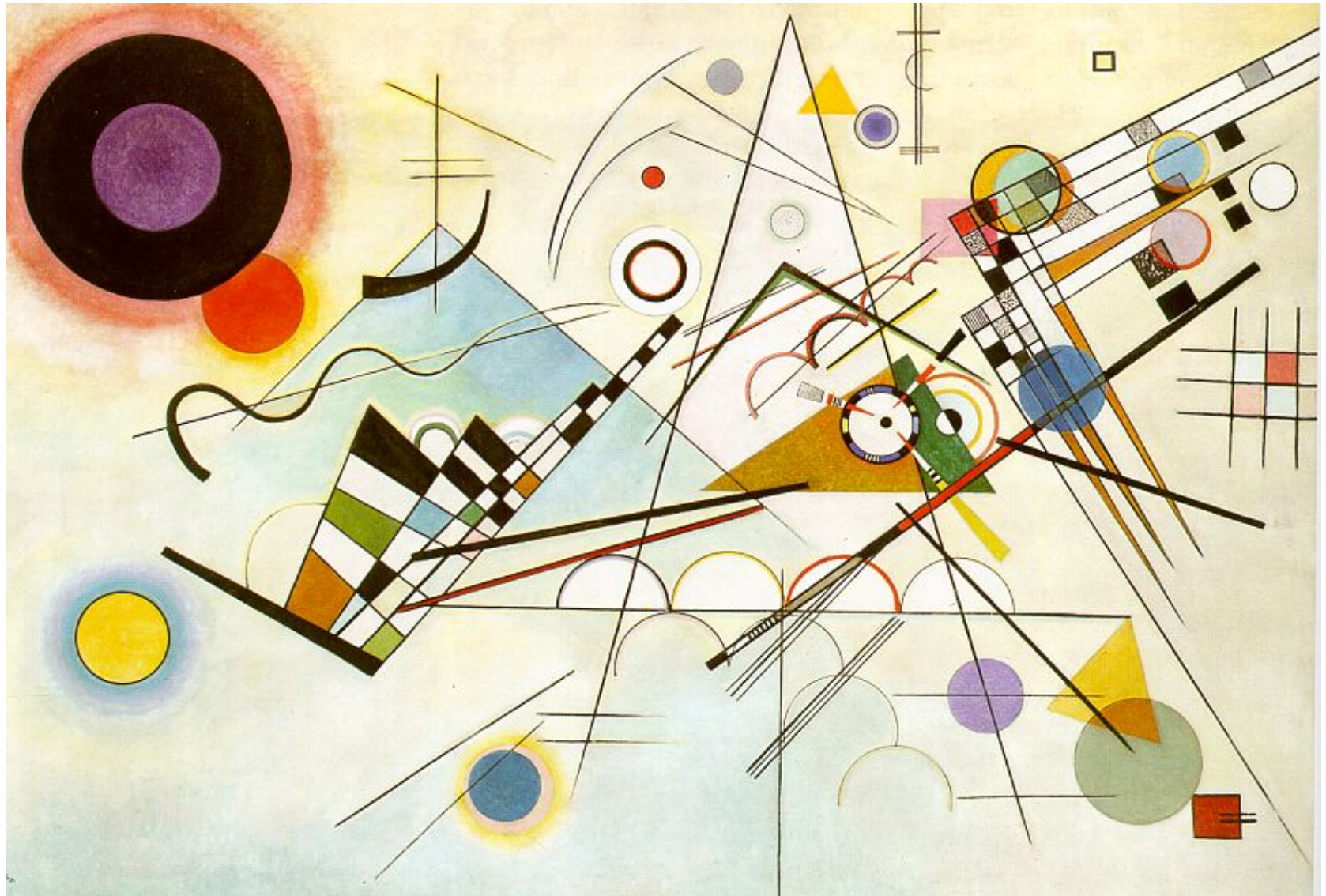


# Aural and visual feedback. The resistance issue.

- As on the **traditional instruments** the higher capacitance of **expressivity** lies on their **resistance**. The physical feedback is very important for the interaction with the medium.
- **Virtuality and disembodiment, deprives resistance.**
- **Aural Feedback is often not enough** for the establishment of an interesting interactive relation.
- **Visual feedback** is carefully being considered as the extended feedback method.
- **Other force-feedback devices** are more than interesting, but far from the **minimal, non-exoskeleton** approach that our research is focused on.



# Point and Line in Plane V. Kandinsky



# Proposed Design Concept

- Accurate rigid model
- 3D cube and classification
- Develop a metaphor, based on Kandinsky's analysis, to relate gesture to geometrical visual representation. (points, lines, triangles, planes ..etc)
- Composition methods will then be combined to the analysis method in order to provide expressive aural feedback.
- Testing and evaluation of the system.