SMART rehabilitation and motion tracking systems to support rehabilitation of people with stroke

Dr Nigel Harris, Royal National Hospital for Rheumatic Diseases

on behalf of the EPSRC EQUAL SMART rehabilitation consortium

http://hsc.shu.ac.uk/smart/

Consortium and Partners

- University of Bath
- RNHRD
- Sheffield Hallam University
- University of Essex
- University of Ulster
- Stroke Association
- Bath Sport and Exercise Science
- Head Injury Unit RNHRD
- Sheffield Teaching Hospitals / Chippenham Stroke Unit
- RUH Bath Care of the Elderly

'To examine the scope, effectiveness and appropriateness of systems to support home-based rehabilitation programmes for older people and their carers'

Why do people go into care ?

- Impact of Stroke @ 6 months
  49% need help bathing
  31% need help dressing
  33% need help with feeding

- Locomotor disability and physical impairment account for 65% of those in care.

More effective rehabilitation will help people remain at home

DOH 2000

Tony Rudd Guys & St.Thomas

Benefit of home rehabilitation

- Cochrane Review Issue 1 2004
  Therapy based rehabilitation services for Stroke patients at home
- Home based exercise programme improves sit-stand in patients with chronic stroke (Monger et al Clin Rehab 2002).
- Dynamic or isometric resistance training improves function and decreases pain in OA (Topp et al Arch Phys Med Rehab 2002).

Rehabilitation – some issues

- Rehabilitation traditionally hands on – technology that can enable and support rehabilitation is not being exploited.
- Repetition is primary contributor to functional recovery but compliance is poor.

'As I get older I am inclined to do less of the things I ought to do and more of the things I want to do.'

Quality and skill acquisition are important !

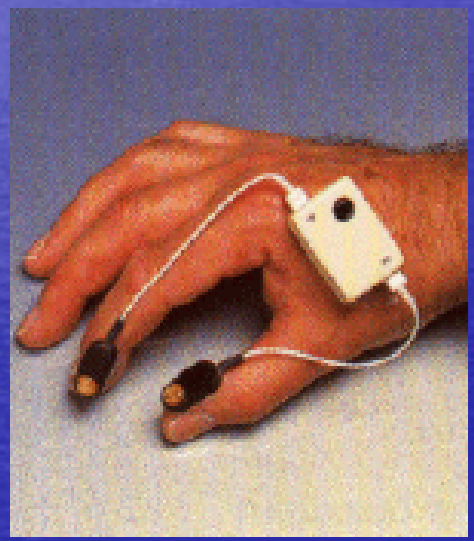
Devices available for motion tracking and rehabilitation

- Switches (Pedometer, Oddstock FES)
- Gyroscopes (angle / rate of turn)
- Accelerometers (velocity)
- Radio frequency, magnetic field
- Video systems
  - Passive (Vicon) or Active (CODA)
- Robot arms (MANUS/MIME)

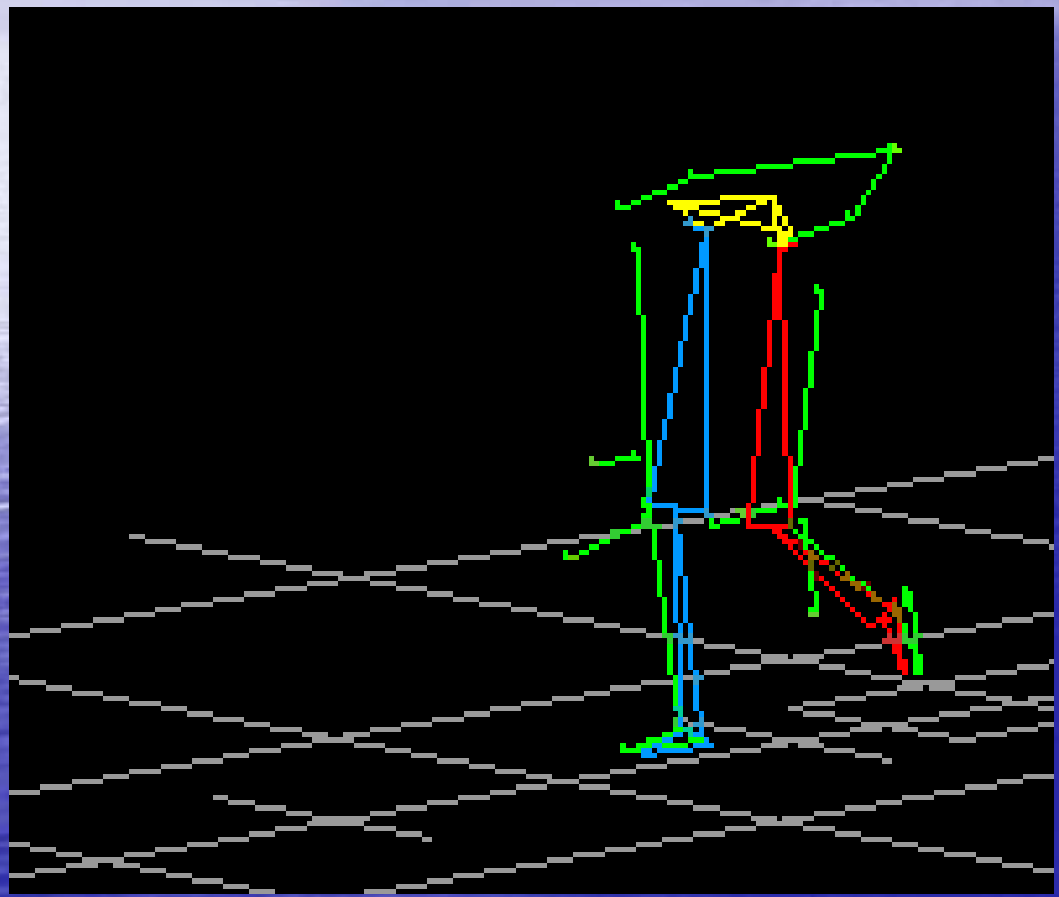
Zheng et al, Med. Biol. Eng. Comp. 2005

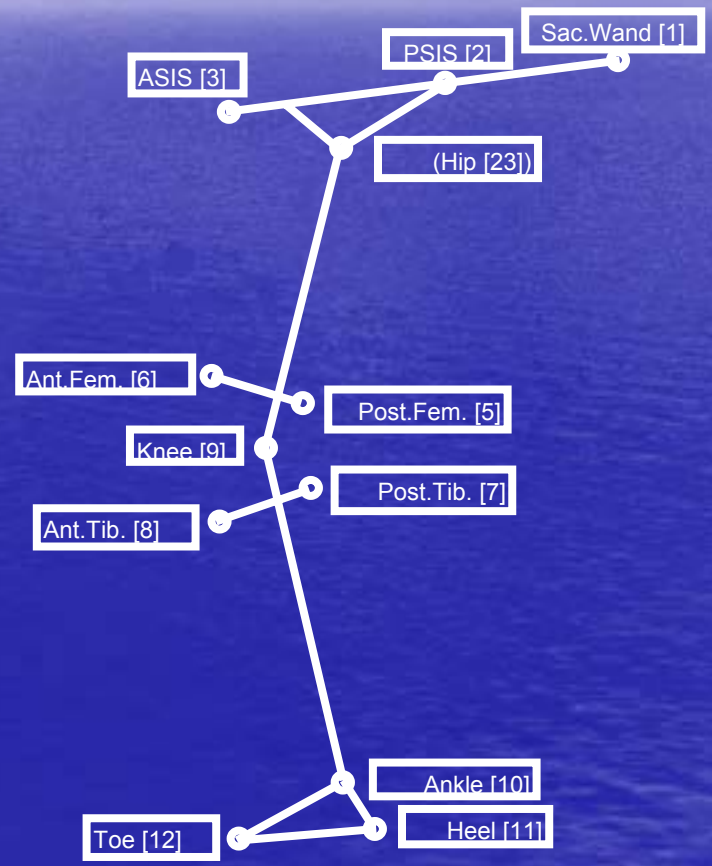
Active video motion capture

Charnwood Dynamics *coda*



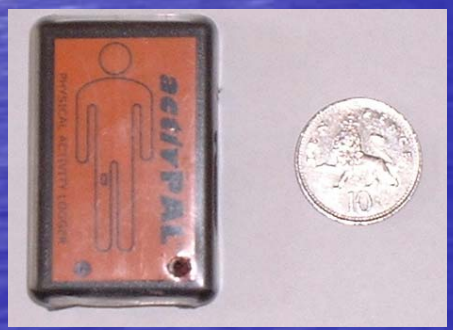
CODA marker placement for gait analysis

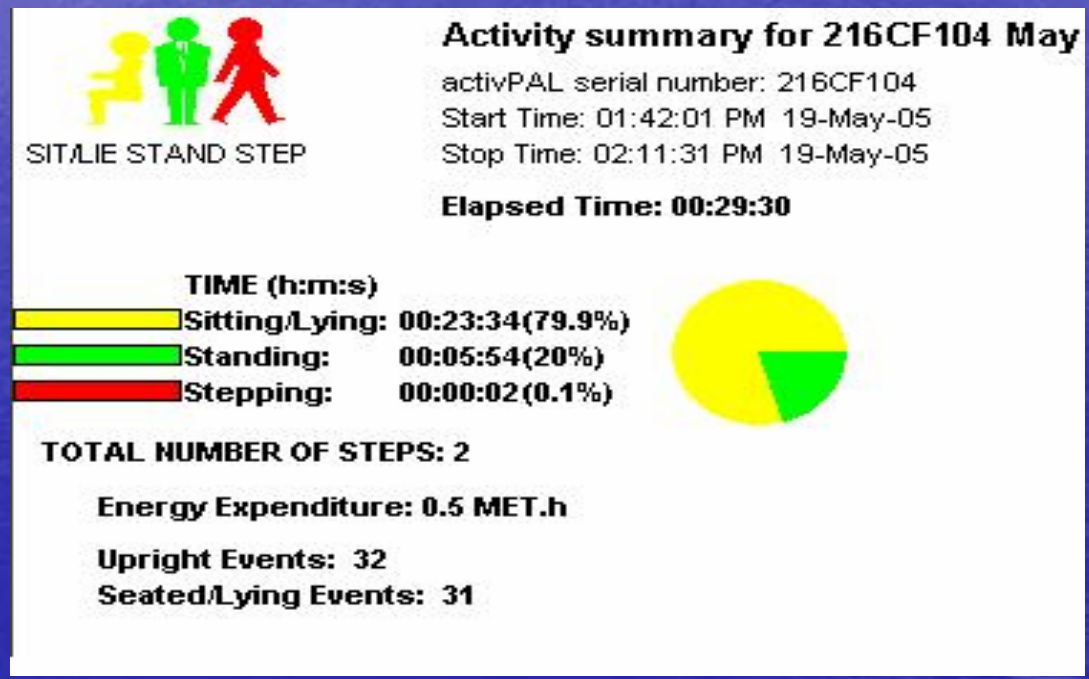




Single axis accelerometer

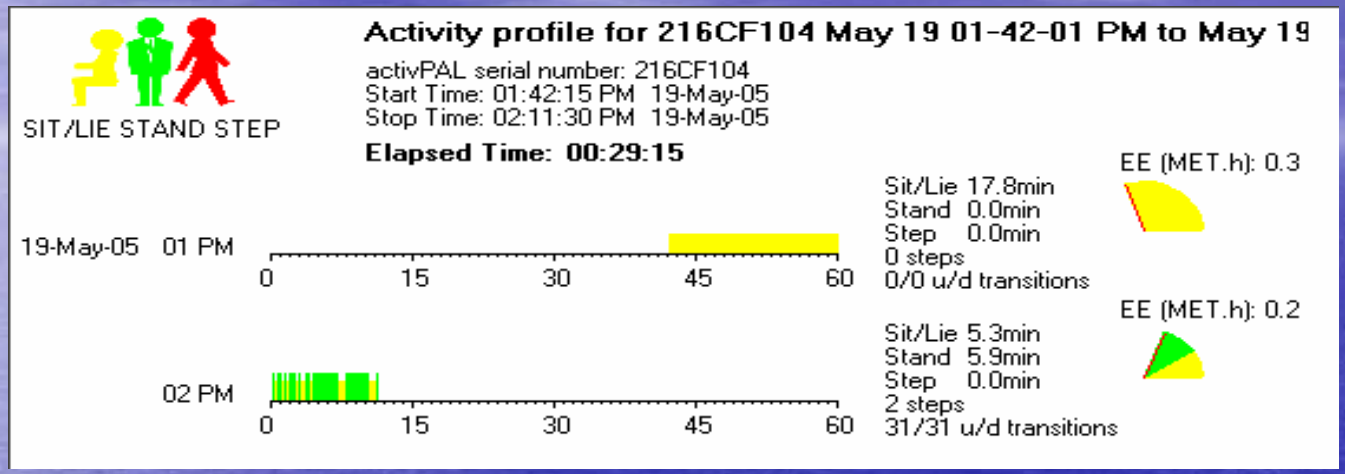
Activpal monitoring of additional in-patient sit to stand practice

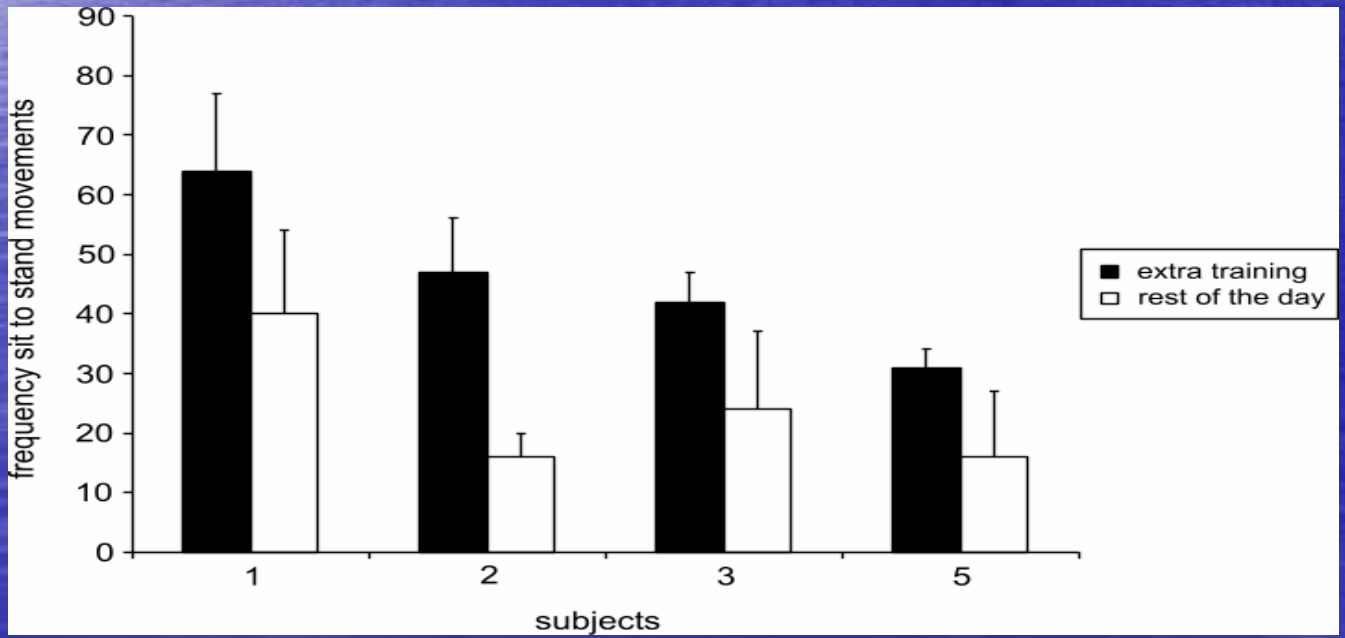




Bratton et al, SRR July 2005

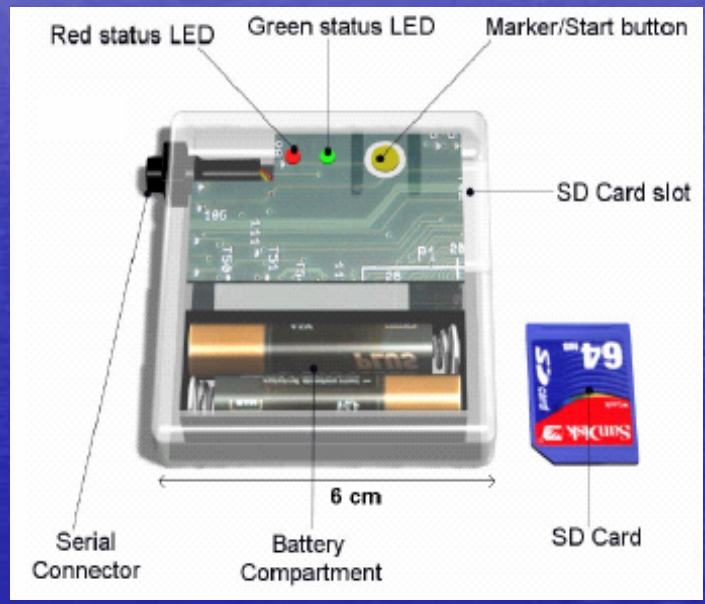
How much extra practice ?





McRoberts MiniMod Accelerometer

- 3 Axis accelerometer
- Data stored on SD memory
- Download, artifact rejection
- Data analysis
- McRoberts gait test
- Assessment of sit to stand performance after Pain Management.



www.dynaport.nl

Royal National Hospital for Rheumatic Diseases NHS

Is the technology appropriate ?

1. Review literature
2. Identify specific rehabilitation interventions
3. Generate rehab movement templates
4. Present scenarios to focus groups
5. Establish design specification
6. Evaluate prototype device with users

Basic types of intervention

- Sit to stand
- Step forward with affected limb

- Reach forward and return upper limb
- Hand to mouth and return (with object)

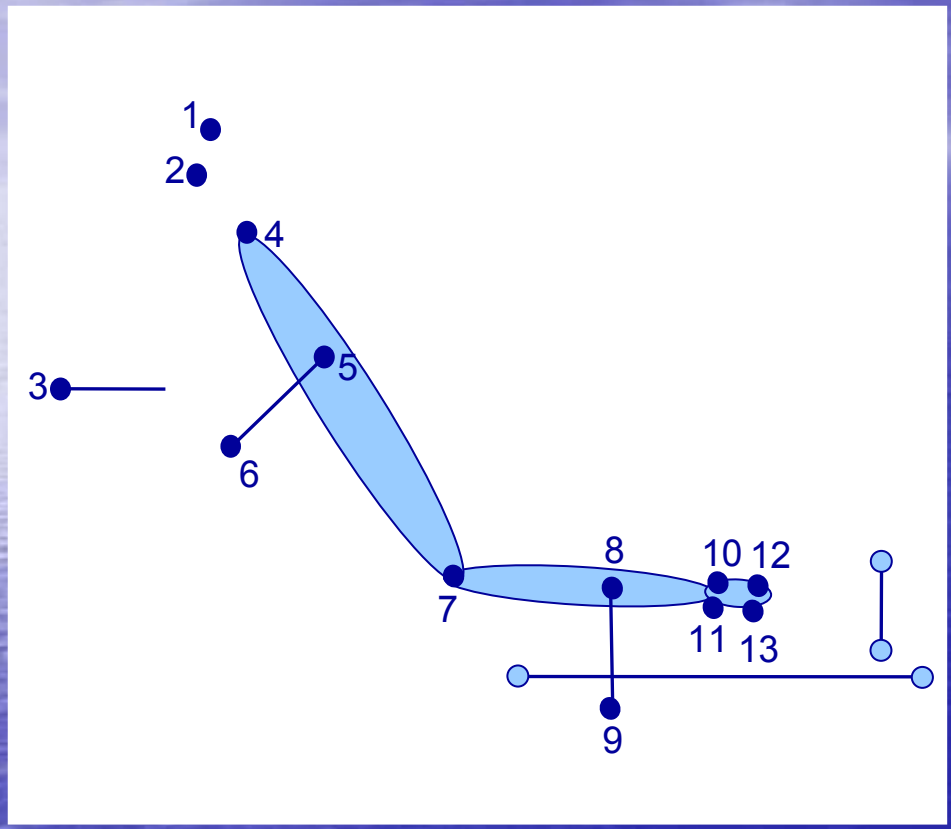
Reference data - functional upper limb activity following stroke

- Pilot investigation of older adult participants
- 1 trial of cyclic drinking activities
- Self-paced repetition

- 3D motion
- Linear and angular measures
- Time derivatives of linear and angular measures
- Joint and segmental measures

Hammerton & Gittoes 2005

UPPER BODY MODEL



Marker	Marker name
1	C3
2	C7
3	T12
4	Acromian
5	UArm wandP
6	UArm wandD
7	Lateral epicondyle
8	LArm wandP
9	LArm wandD
10	Radial styloid
11	Ulna styloid
12	3mcp
13	5mcp

4 segment model

13 segmental markers

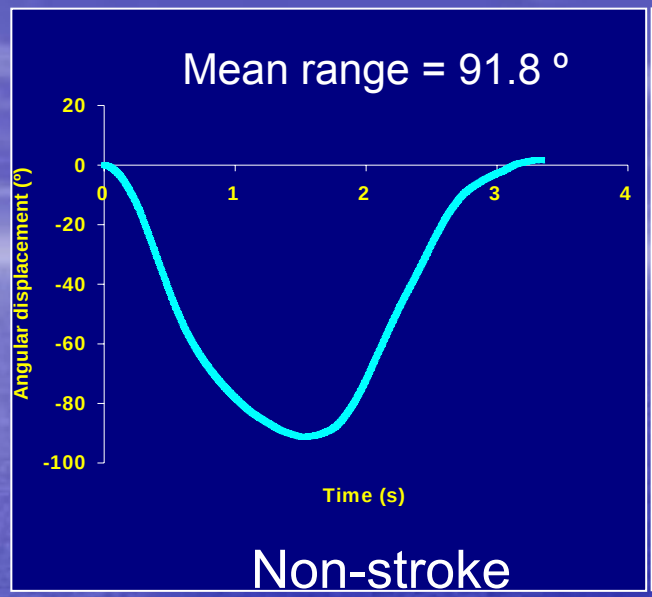
4 supplementary markers

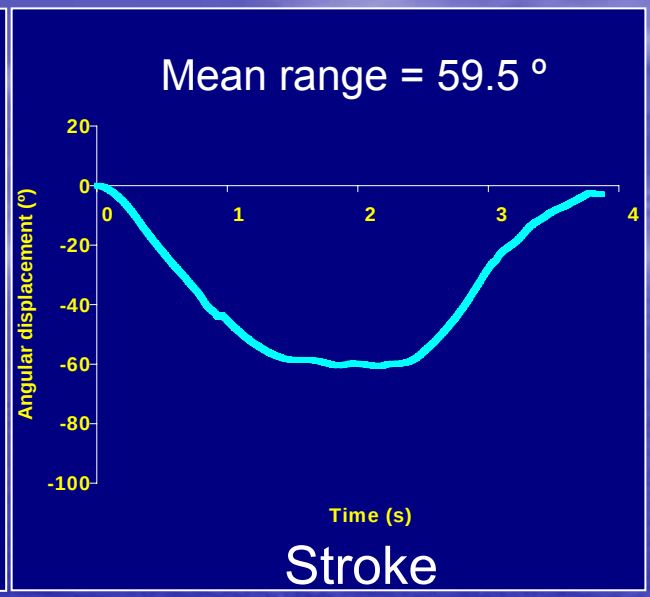
TEMPORAL CHARACTERISTCS OF DRINKING

	Non-Stroke	Stroke
Cycle duration (s)	3.28	3.76
Upward phase (s)	1.63 (49.7%)	1.97 (52.4%)
Downward phase (s)	1.60 (48.9%)	1.67 (44.2%)

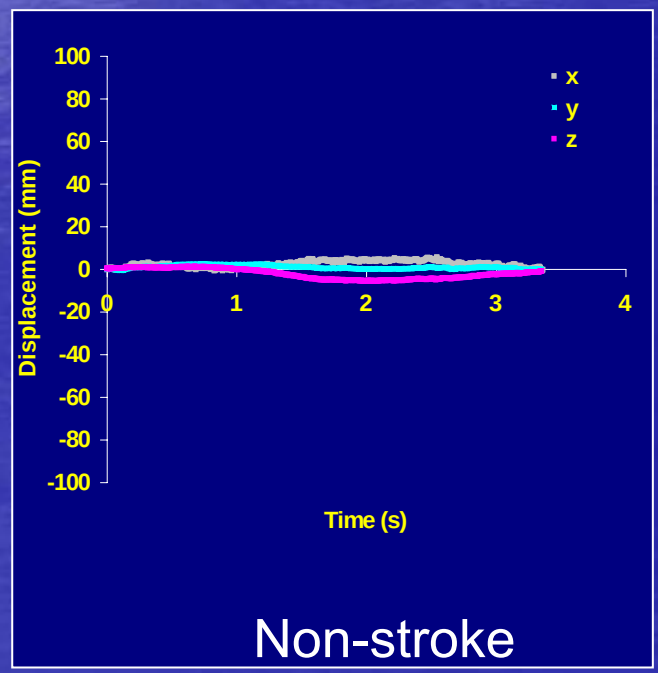
Hammerton & Gittoes 2005

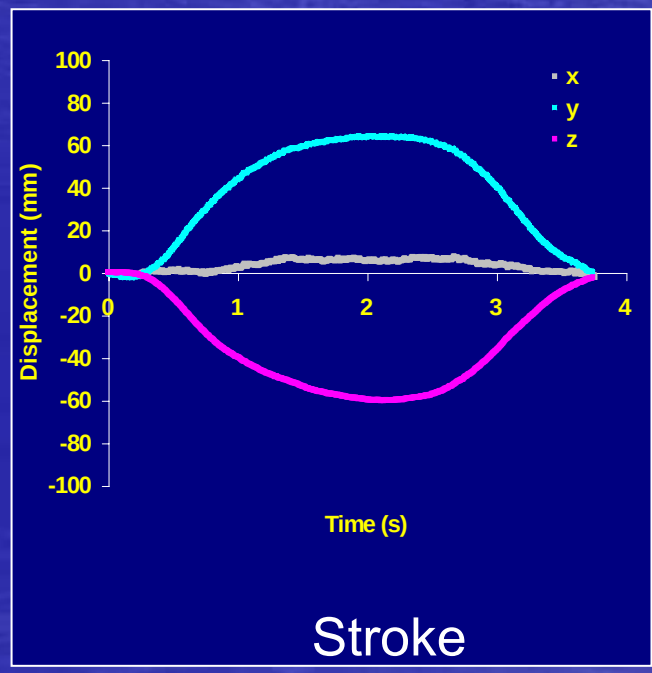
Elbow Flexion / Extension





Trunk (T12) Deviation



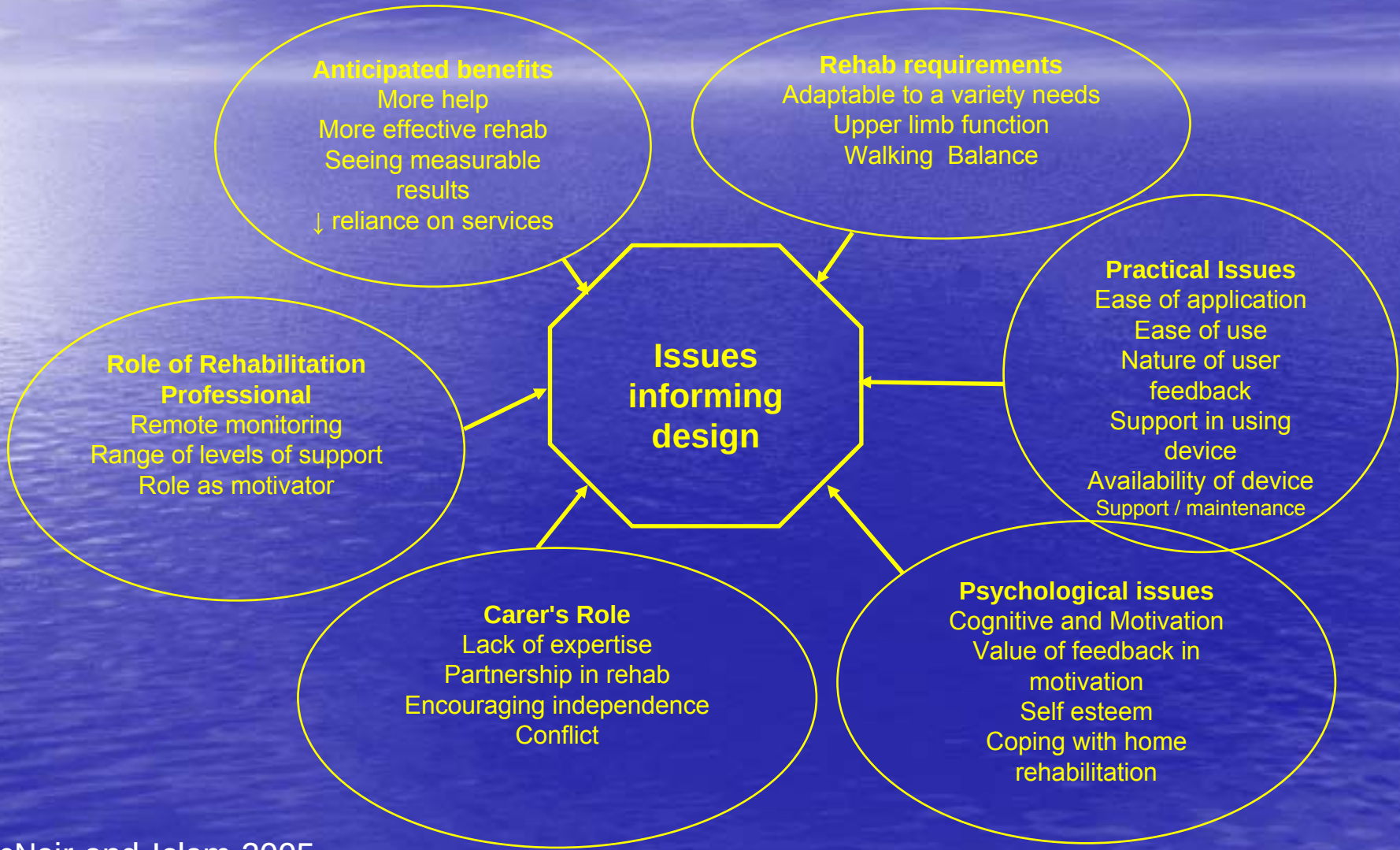


KEY MEASURES

- Cycle durations
- Phase durations (e.g. cup to mouth)
- Range of joint motions (elbow flexion/extension)
- Segment deviation (trunk motion)
- Interaction of joint actions (coordination)
- End effector peak velocity

How much data, real time or summary ?

Experience of rehabilitation



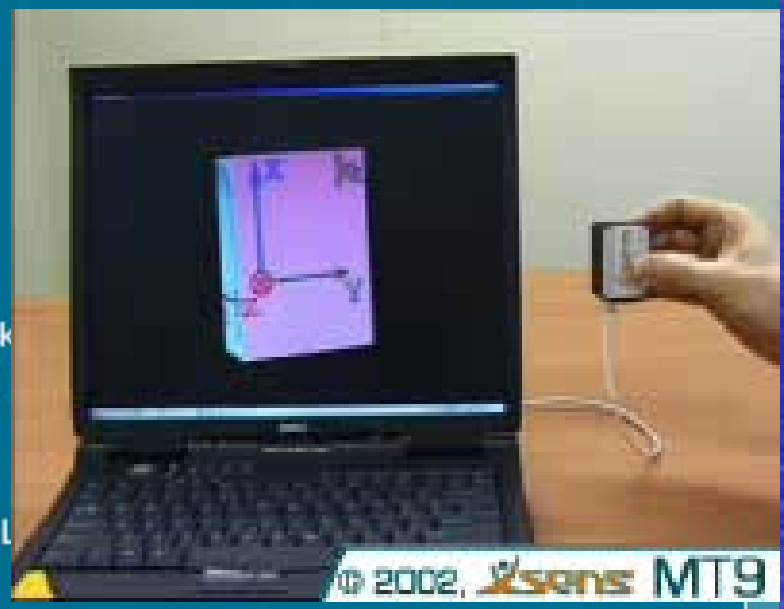
McNair and Islam 2005

MT9 motion tracking system (MTS)

		rate of turn	acceleration	magnetic field
Unit		[deg/s]	[m/s²]	[mGauss]
Dimensions		3	3	3
Full Scale	(units)	+/- 900	+/- 20	+/- 750
Linearity	(% of FS)	0.1	0.2	1
Bias stability	Compensated (units 1σ)[4]	5	0.02	0.5
	Uncompensated (units per °C)[5]	1	0.02	-
Scale factor stability	Compensated (% 1σ)[4]	-	0.05	0.5
	Uncompensated (% per °C)[5]	0.15		
Noise	(units RMS)	0.7		
Alignment error[7]	(deg)	0.1		
Bandwidth	(Hz)	50		

Physical Specifications

Interface:	Serial (RS-232 max 460k
Operating Voltage:	5.5 V (adapter available)
Supply Current:	40 mA
Ambient Temperature Operating Range:	0°C - 55°C
Outline Dimensions:	39 x 54 x 28 mm (W x l
Weight:	35 g



MT9 motion tracking system

MTS evaluation with CODA

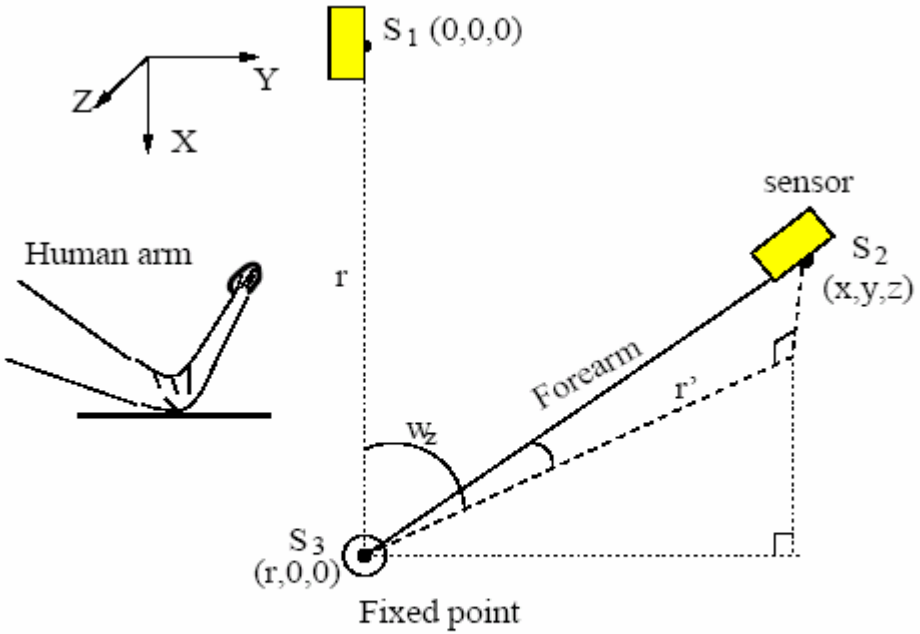
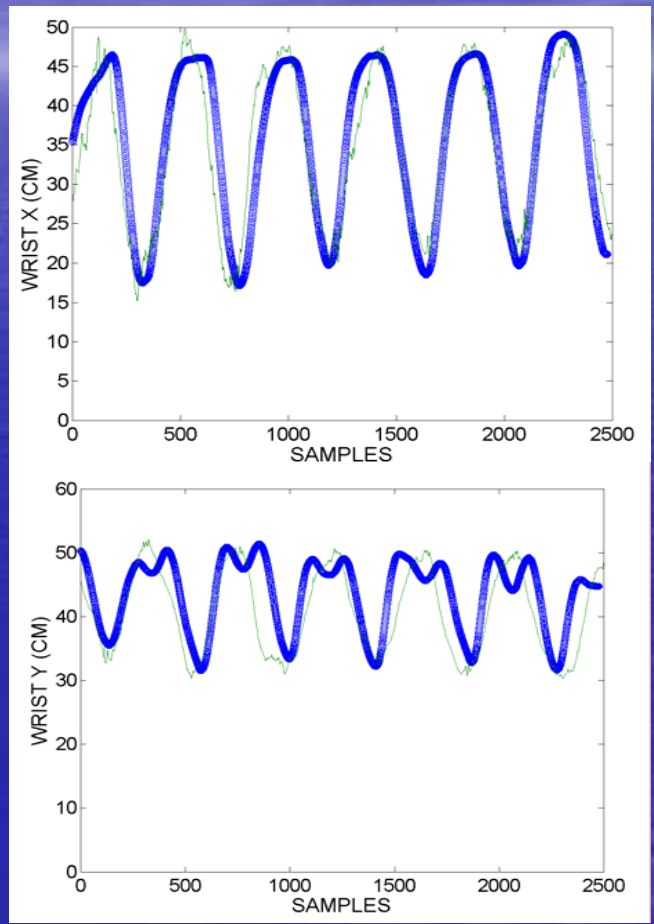


Fig. 1. Kinematics of a human forearm (the fixed point is the elbow joint).



Zhou and HU IEEE EMBC 2005

Motion Tracking System (MTS)

1. MTS built into bean bag / hat or clothing
2. Record target manoeuvre with therapist

3. Patient replicates the movement
4. System records data (quality and quantity)
5. Data downloaded to base station
6. Feedback to patient and carers
7. Feedback to HCP's

Barriers to the use of technology by older users

- Negative self image
- Lack of understanding of technology
- Lack of trust in technology
- Operational anxiety following a bad experience

Project time table
(where are we ?)

- Reference data
- Focus groups (hardware and user interface)
- Evaluation of prototype
- Pilot studies on hospital patients
- Home based trials (January 2006)
- Evaluate performance - users and HCP's

This work finishes November 2006

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