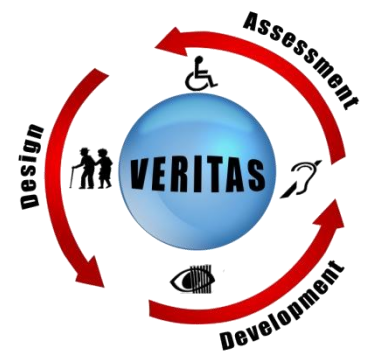




VERITAS project

FP7 247765



Abstract Physical Model



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Scope

- To provide descriptions of physical disabilities:
 - **Abstract description of functional limitations**
 - Abstract descriptions use parameters and metrics that are *abstract*, meaning independent of modeling implementations and software tools.



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Abstract vs model parameters

- Abstract parameters describe functional limitations (e.g., pull force at hand, movement time in an aiming task, etc.)
- Model parameters are parameters of a specific model implementation (e.g., muscle forces, control feedback loop gains, ACT-R parameters, etc.)

○ Requirements:

- Abstract parameters must be easy to map onto model parameters (see later)
- Abstract parameters must be measurable (see later)



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Prioritization of disabilities

- Physical disabilities have been prioritized according to:
 - A) prevalence
 - B) affordability and effectiveness of treatments
- 15 Motor disabilities:
 - 9 of ICD-10 M block; 5 of G block, 1 of I block
- 4 Visual disabilities:
 - 4 of ICD-10 H block
- 9 Speech and Hearing disabilities:
 - 9 of F, H, R ICD-10 blocks



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Motor disabilities

ICD 10 Code	Pathology
M05 – M06	Rheumatoid Arthritis
M10	Gout
M16	Coxarthrosis (osteoarthritis of the hip)
M17	Gonarthrosis (osteoarthritis of the knee)
M18	Arthrosis of First Carpometacarpal Joint
M40	Kyphosis and lordosis
M45	Ankylosing spondylitis
M50 – M51	Cervical disc disorders and other intervertebral disc disorders

ICD 10 Code	Pathology
I64	Stroke

ICD 10 Code	Pathology
G20 – G22	Parkinson's Disease
G24	Dystonia
G35	Multiple Sclerosis
G60	Hereditary and idiopathic neuropathy
G80 – G83	Cerebral Palsy



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Visual disabilities

ICD 10 Code	Pathology
H35.3	Senile macular degeneration
H36.0	Diabetic retinopathy
H40	Glaucoma
H53.5	Color vision deficiencies



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Speech disabilities

ICD 10 Code	Pathology
F98.5	Stuttering
F98.6	Cluttering
H91.3	Muteness no speech
R47.0	Dysarthria
R48.2	Apraxia of speech



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Hearing disabilities

ICD 10 Code	Pathology
H90.0-H90.2	Conductive hearing loss, bilateral, unilateral with unrestricted hearing on the contralateral side or unspecified
H90.2-90.5	Sensorineural hearing loss, bilateral, unilateral with unrestricted hearing on the contralateral side or unspecified
H90.6-H90.8	Mixed hearing loss conductive and sensorineural hearing loss, bilateral, unilateral with unrestricted hearing on the contralateral side or unspecified
H91.9	Hearing loss, unspecified



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Motor abstract model (M block)

- Diseases of the musculoskeletal system and connective tissue (M00-M99) affects:
- Kinematics functions, which are related to:
 - mobility of joints and bones (ICF b710-b720)
 - sometimes structures related to movements (ICF s7xx – not considered).
- Dynamics functions, which are related to:
 - Muscle power functions (b730x)
 - Muscle tone functions (b735x)
 - Muscle endurance functions (b740x)



Kinematics functions metrics

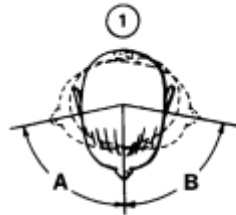
- Mobility of joints and bones (ICF b710-b720). Are well described by the **range** and **speed** of motion of joints
 - Easily measurable
 - Easy to map onto internal model parameter
- Exception: spine abstract parameters are overall flexion and torsion (observable) whereas parameter of model implementations might be angles between vertebrae.



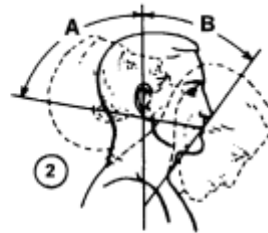
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Kinematic functions metrics

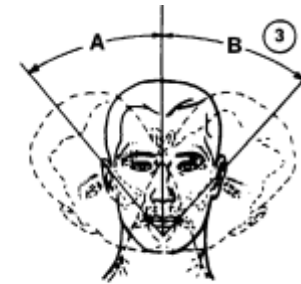
- Example: Reumathoid arthritis
 - mobility of the neck.



Neck Rotation
Right (A) Left (B)



Neck Extension [A]
Flexion (B)



Neck Lateral Bend
Right (A) Left (B)

	males mean (std)	females mean (std)	able-bodied males (5-95 perc.)	able-bodied females (5-95 perc.)
rotation	69° (10°)	66° (11°)	73.8° -99.4°	73.6° -108.9°
extension	69° (14°)	64° (16°)	65.4° -103°	64.9° -103°
flexion	46° (6°)	46° (10°)	34.5° -71°	46° -84.4°
lateral bend	70° (15°)	66° (15°)	70.4° -127°	66.1-140.4



Muscle functions metrics

- **Force at end-effectors** (hands, fingers, etc.) are observable.
- Example: Reumathoid Arthritis Grip strenght:

	RA (50 patients) mean (std)	Able-bodied mean
Grips strenght (N)	103.8 (69.4)	262 (right hand)
Pinch strength (N)	32.8 (22.2)	58

- N.B. Tone, power, endurance of *single muscles* are difficult to observe. They are internal model parameters to be identified.



Motor abstract model (G-I)

- Diseases of the nervous system (G00-G99) and stroke (I64) affects:
- Movement (control/dexterity) functions, which are related to:
 - Control of voluntary movement functions (b760)
 - Involuntary movement functions (b765)
 - Gait pattern functions (b770)
 - Motor reflex functions (b750)
 - Involuntary movement reaction functions (b755)
 - etc.



Movement functions metrics

- Metrics for movement functions related to neuro-muscular diseases are **task specific performance indicators:**

- Point to point motion task (20 indicators)
 - Fitts' law parameters
 - Movement time, dwell time, jerk, etc.
- Continuous tracking tasks (7 indicators)
 - rms error, std deviation of speed, etc.
- Hold task (2 indicators)
 - mean error, std deviation
- Gait parameters (7 indicators)
 - Stride length, gait cycle, speed, cadence, etc.



Movement functions metrics

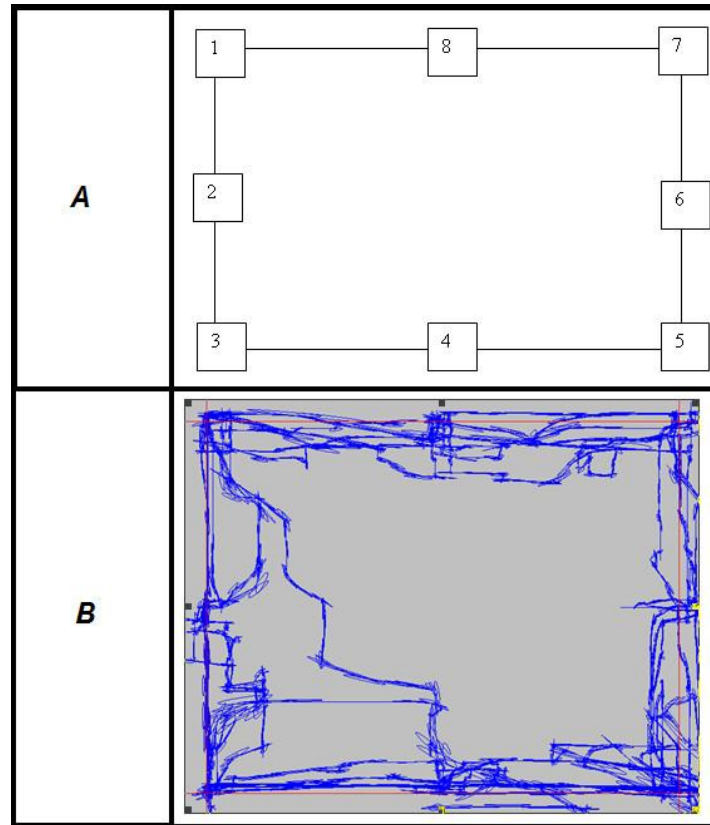
- Clinical scales are not useful for modelling virtual users
- Examples of clinical scales:
 - Stroke:
 - Functional Independence Measure (FIM)
 - Fugl-Meyer Assessment
 - Wolf Motor Function Test
 - Chedoke-McMaster Stroke Assessment
 - Parkinson's disease
 - Unified Parkinson's Disease Rating Scale (UPDRS)



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Movement functions metrics

- Example 1. Stroke. Point to point task

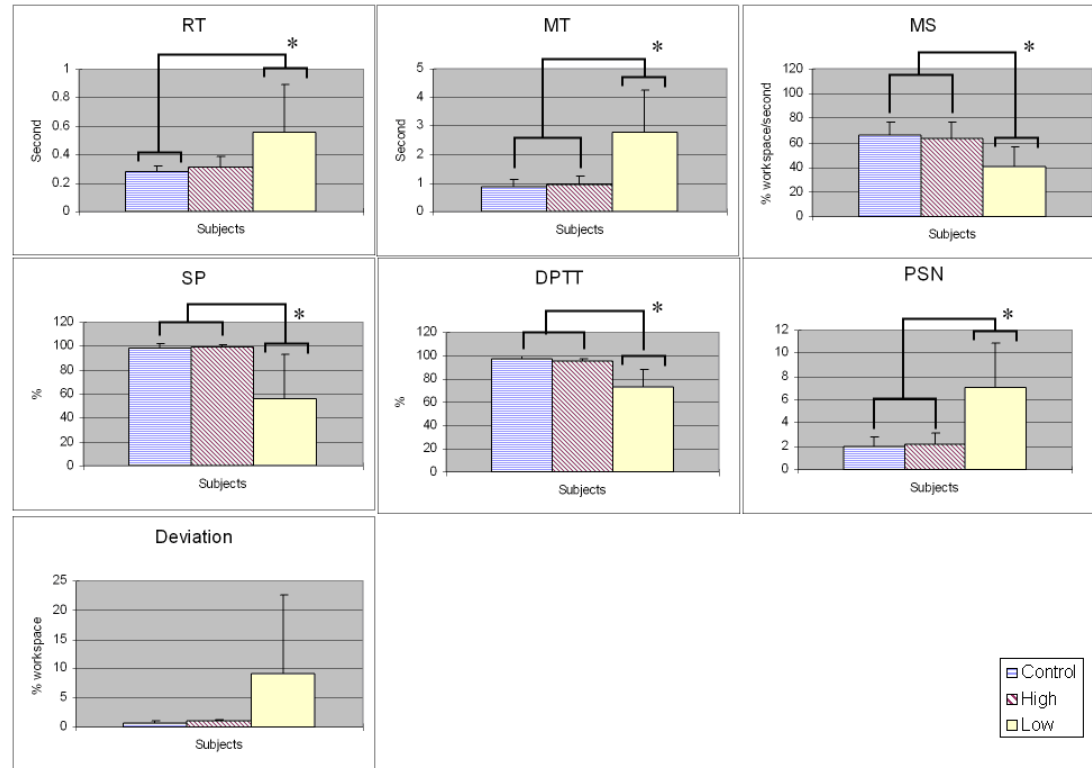


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Movement functions metrics

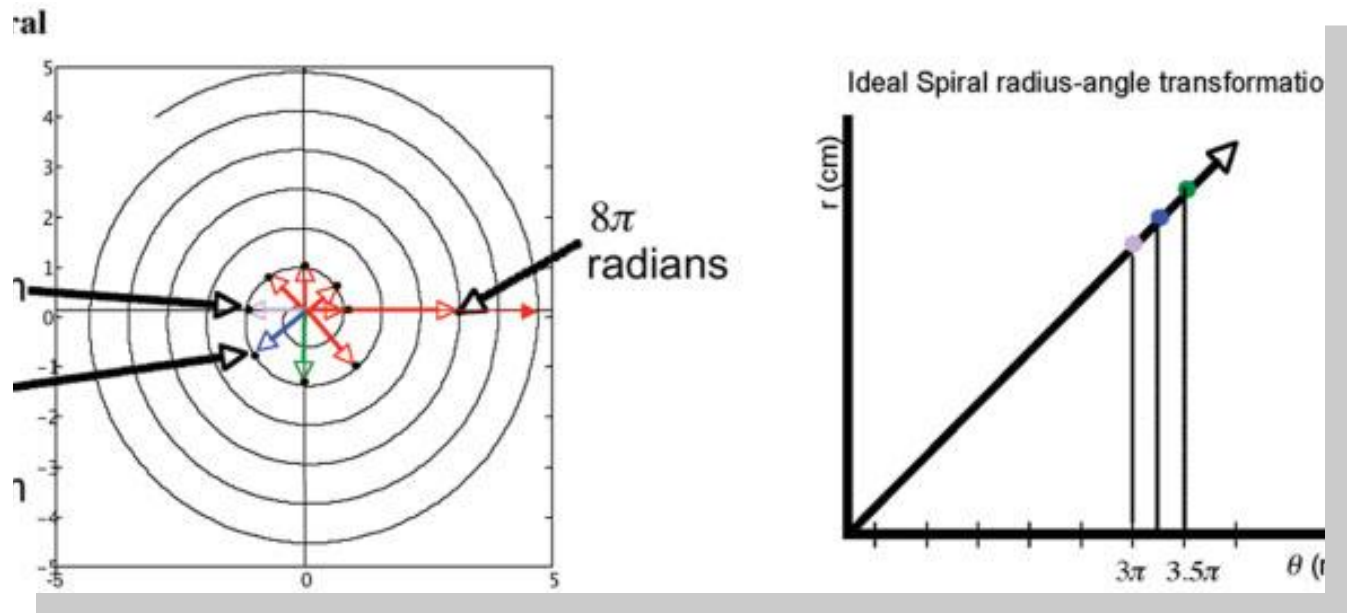
○ Example 1. Stroke. Point to point task

- Target acquisition test. DPTT: dwelling percentage time in target, MS: movement speed, MT: movement time, PSN: peak speed number, RT: reaction time, SP: success percentage.



Movement functions metrics

- Example 2. Parkinson's disease
 - Spiral test



Movement functions metrics

○ Example 3. Fitts' law

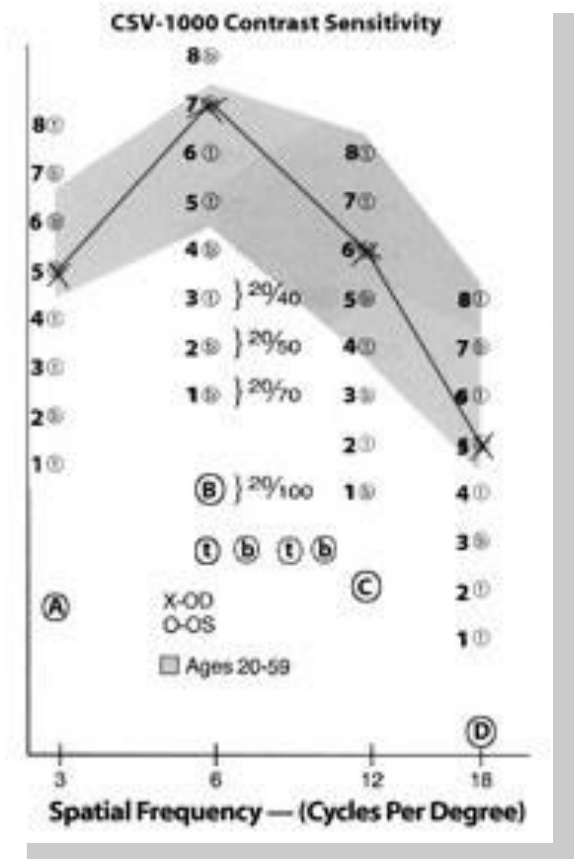
- Fitts' law is a model of human movements.
- <http://fww.few.vu.nl/hci/interactive/fitts/>

$$MT = a + b \log_2 \left(2 \frac{A}{W} \right)$$

	Able-bodied mean (std)	PD mean (std)
a (ms)		
b (ms)	119 (29)	178 (71)

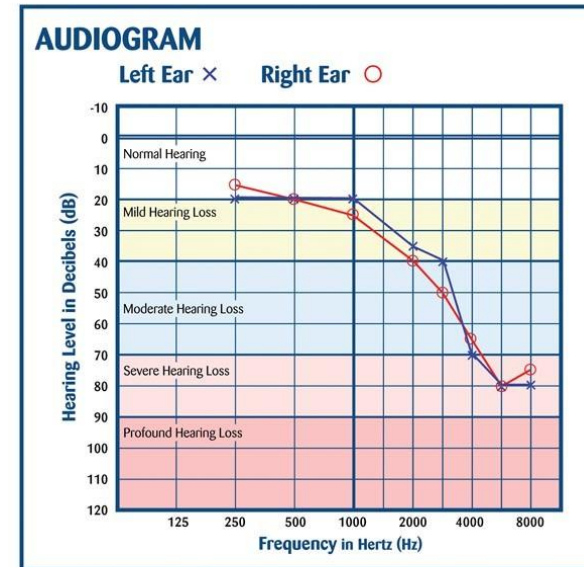
Visual abstract model (H block)

- Metrics (well establish measurement methods)
 - Visual acuity
 - Visual field
- Metrics
 - Contrast Sensitivity
 - Glare sensitivity
 - Color vision deficiencies



Speech/ Hearing model (H bl.)

- Metrics for hearing
 - Audiograms



* An example presbycusis (sloping high-frequency hearing loss) synonymous with the ageing process.

- Metrics for speech
 - PCC (percentage of consonants correct)
 - ACI (articulation of competence index)

Measurability

- Abstract model parameters must be measurable



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Conclusions

- 15 motor disabilities (motor and neural)
- 4 visual disabilities
- 5 speech and 4 hearing

- Indicators
 - Objective, measurable, suited for virtual users modelling
 - Some indicators are task related performance indices, which need tuning of model parameters
 - Measurement methods are available to supplement literature data

