

Skills Representation and Encoding

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Overview

- ▶ Representation of Skills
- ▶ SubSkills
- ▶ Digital Formats
- ▶ Descriptors



Representation of Skills

- ▶ What is a Representation?
 - A Mapping from the real thing into a lower dimensional space with associated meaning
- ▶ There are many representations of the same thing
 - Depending on the purpose
 - Depending on the observer
- ▶ Let's make it more practical

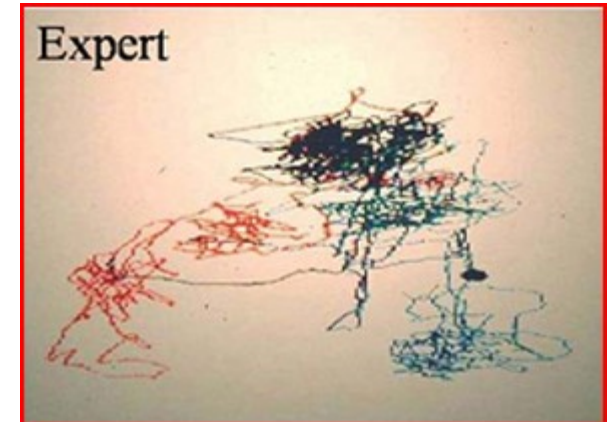
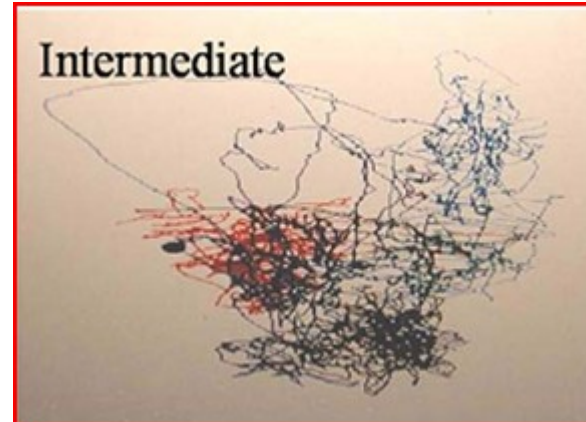


Digital Representation of Skill

- ▶ Express the Skill in terms of mathematical terms and algorithms
- ▶ Find the Digital Encoding of the Skill
 - Which are the codecs for the skills?
 - Which discretization?
 - Which mathematical functions?
- ▶ Which is the focus of our Representation?
 - Not visualizing, not understanding
 - *Manipulating and Transferring the Skill*



Signature of Skills



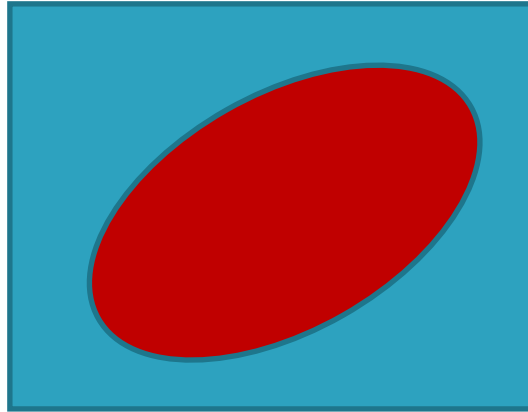
Hand motion signature of tying a laparoscopic knot, showing the quantitative and qualitative differences between novice, intermediate and expert surgeons.

Courtesy Sir Ara Darzi, MD, Imperial College of London, 2001

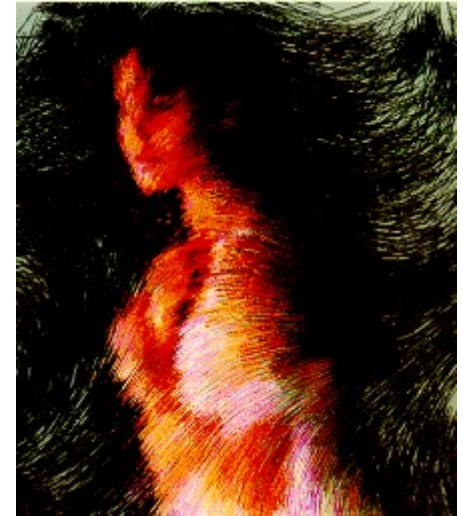
Different Representations



pixels



vectorial



strokes

Which are the equivalent representations for a Skill?



Decomposing Skills

- ▶ How we can decompose the Skill in primary components?
 - Which are the main elements of Tennis playing?
- ▶ A Subskill is an elementary unit of skillfulness that can be shared across different skills
 - Coordination and Balance are examples
- ▶ Subskill can be roughly organized in
 - Sensori-motor
 - Cognitive
- ▶ It is important to remember that Subskills are instantiated in a given skill, and they have strong relationships each other



Describing SubSkill

- ▶ Various elements of SubSkill
- ▶ Complexity
- ▶ Sensori-motor channels
- ▶ Performance Evaluation

- ▶ In addition we identify variables and algorithms that are associated to the given Subskill
 - For example the Coordination



Sensorimotor SubSkills

- ▶ Balance and postural control
- ▶ Bi-manual Coordination
- ▶ Hand-eye coordination
- ▶ Interpersonal coordination
- ▶ Perception-by-touch
- ▶ Prospective control
- ▶ Proximal-distal coupling
- ▶ Respiratory / movement coupling



Perception-by-touch

Description	Touch refers to the coetaneous component of the haptic modality. Various receptors that are embedded in the skin (dermis) providing information about mechanical properties, temperature and pain. There are four types of mechanoreceptors and the integration of their information, (spatial and temporal) serves the basis for the feeling of vibration, compliance and roughness.
Complexity	Difficulty depends on the intensity to detect or the similarity between the physical intensities to be distinguished and on the level of "noise" involved in perception, either from external sources (e.g., vibrations of the tool used) or internal ones (e.g., emotional distress).
Support of other Sensori-motor channels	Touch can be augmented by movements ("exploratory procedures").
Performance Evaluation	Absolute threshold - The smallest intensity identified; Just Noticeable Difference (JND) - The smallest difference in intensity identified; Sensitivity - The level of ability to distinguish between two (or more) intensities across different response propensities; Magnitude Estimations - Psychological mapping of different physical intensities.
Related Skills	Fine motor control and fine force control.



Prospective control

Description	Prospective control refers to the anticipation of future place-of contact and time-to-contact based on spatio-temporal information contained in optic, acoustic, or haptic energy arrays. Prospective control requires the coupling between movement parameters and information contained in various energy arrays.
Complexity	Prospective control can increase in complexity based on the continuous/discrete availability of information, the amount of time available, the types of movement being considered.
Sensori-Motor channels	All channels are concerned by prospective control, including the visual system, the auditory system, and the somato-sensory system. All systems can complementarily specify place-of and time-to future contacts with objects or events.
Performance Evaluation	Movement initiation, movement-information coupling variables
Related Skills	Bimanual coordination - Postural control - Eye-hand coordination



Cognitive SubSkills

- ▶ Control flexibility and attention management skills
- ▶ Coping strategies and alternative response schemas
- ▶ Memory organization, structure and development of knowledge schemas
- ▶ Perceptual Observational
- ▶ Procedural skills



Procedural Skills

Description	Procedures are sequences of ordered activities that need to be carried out in the performance of tasks, the same procedure had to be repeated every time the same task segment is performed (e.g. the procedures of filling water, preparing coffee ingredient and brewing water, when using a coffee machine). Performance of every task can be subdivided into a large number of procedures, the competence in the performance of which is developed with training.
Variables affecting difficulty and load	The difficulty and load of procedures is modulated by the number of composing elements, time, order and accuracy constraints, compatibility of elements, interference, confusion and competition with other procedures.
Behavioral manifestations and performance measures	Speed, accuracy and completeness of performing procedures, and the transition smoothness from one to another within procedure activity, number of intrusions, confusions and amount of interference from other procedures.
Progress with practice and training	Novice, low skill performance is slow, effortful and under a close conscious supervision. Elements of procedures are skipped or not performed in order. Procedures are easily confused and interfered by other procedures. All of these problem are reduced or completely disappear in expert performance, procedures are performed rapidly, smoothly, as a unified response unit, requiring little conscious supervision.

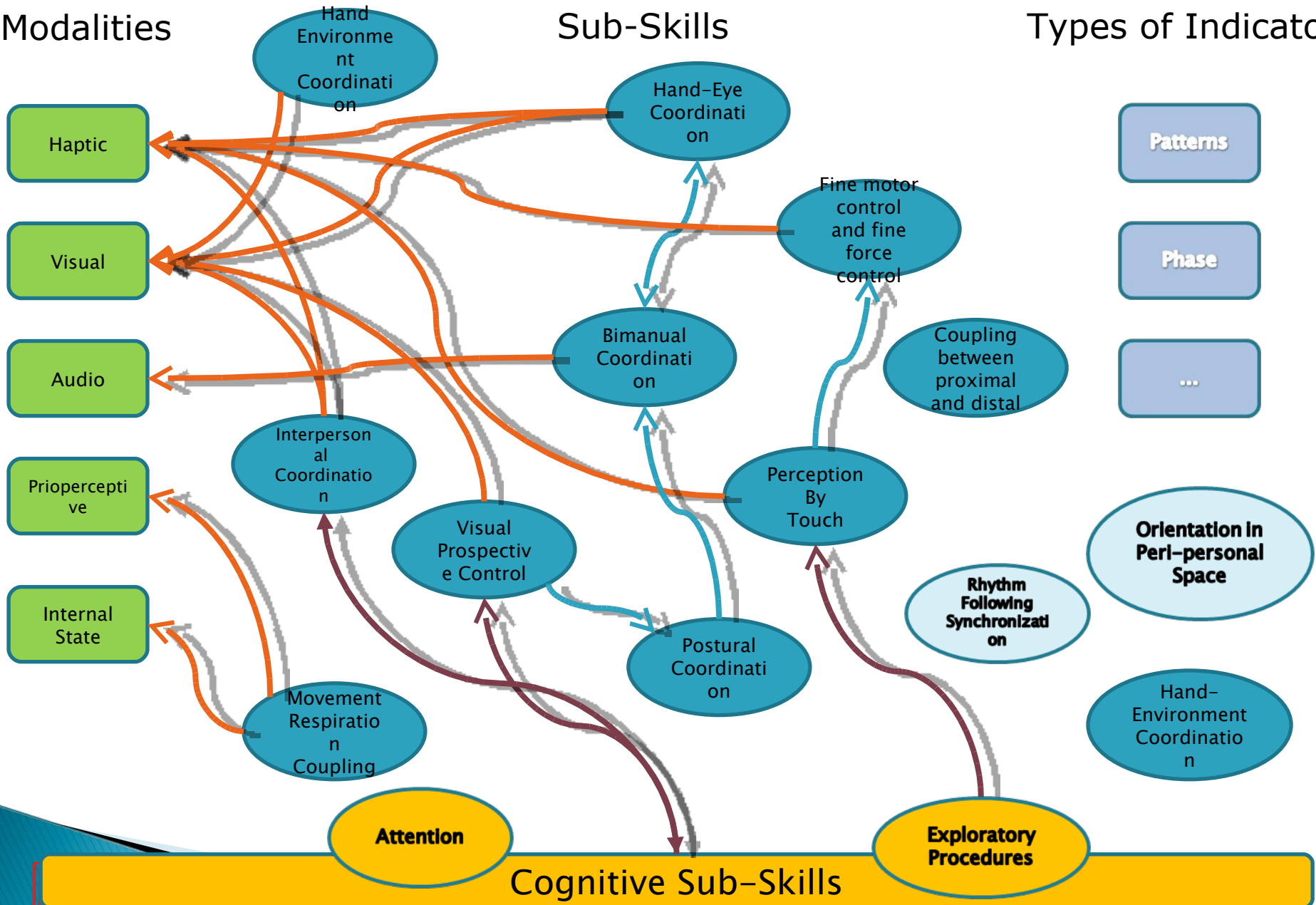


SENSORY-MOTOR SUB-SKILLS MAP

Modalities

Sub-Skills

Types of Indicators



Representation Levels



Every level is affected by the following, that is the processed data depend on the specific Subskill. At the highest level, the Skill level, we find the relationship among Subskills.



Digital Encoding

- ▶ The Digital Encoding is the selection of the Algorithms, Transformations and Quantizations applied to the Skills Data
- ▶ There is the need to encode the data in digital format
 - From low level to the highest level
- ▶ The encoding should be flexible to be adapted to the research progress



Digital Format for Skills

- ▶ Low level formats
 - Standard formats for audio and video
 - Many formats for low level gestures
- ▶ Medium level and High Level
 - Descriptors and Annotations
- ▶ A Descriptor is a generic property associated to a given entity
 - Computed from a set of algorithms
- ▶ Annotations are used to attach information to time sequences



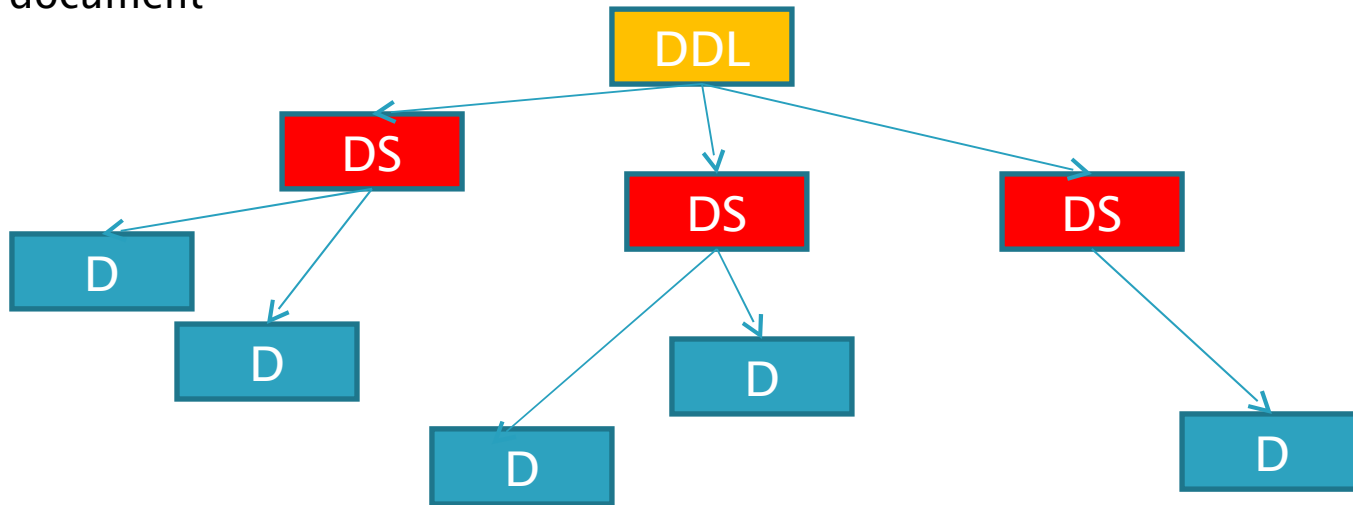
MPEG-7 ISO 15938

- ▶ MPEG-7 is the existing standard for describing Multimedia Data
- ▶ Description Only
- ▶ No Algorithms for extraction of Description
 - Anyway some Descriptors are based on standard algorithms
- ▶ MPEG-7 Focuses on
 - Indexing
 - Authoring
 - Management
- ▶ Extensions of MPEG-7 are possible
 - Flexible XML Schema Format
- ▶ HAML by Ottawa University for describing Haptic Content



MPEG-7

- ▶ Descriptor Schema based format for the description and annotation of multimedia data
- ▶ DS are organized in types and represented as XML data for human interpretation
- ▶ DDL Description Definition Language, the XML Schema-based declarative language that the majority of the syntax of the standard is written in
- ▶ Descriptor: a basic unit of description
- ▶ Description Scheme: a combination of DSs and/or Ds, written in the DDL, and expressing a relationship between these description units
- ▶ An instantiated Description Scheme, which is natively expressed as an XML document

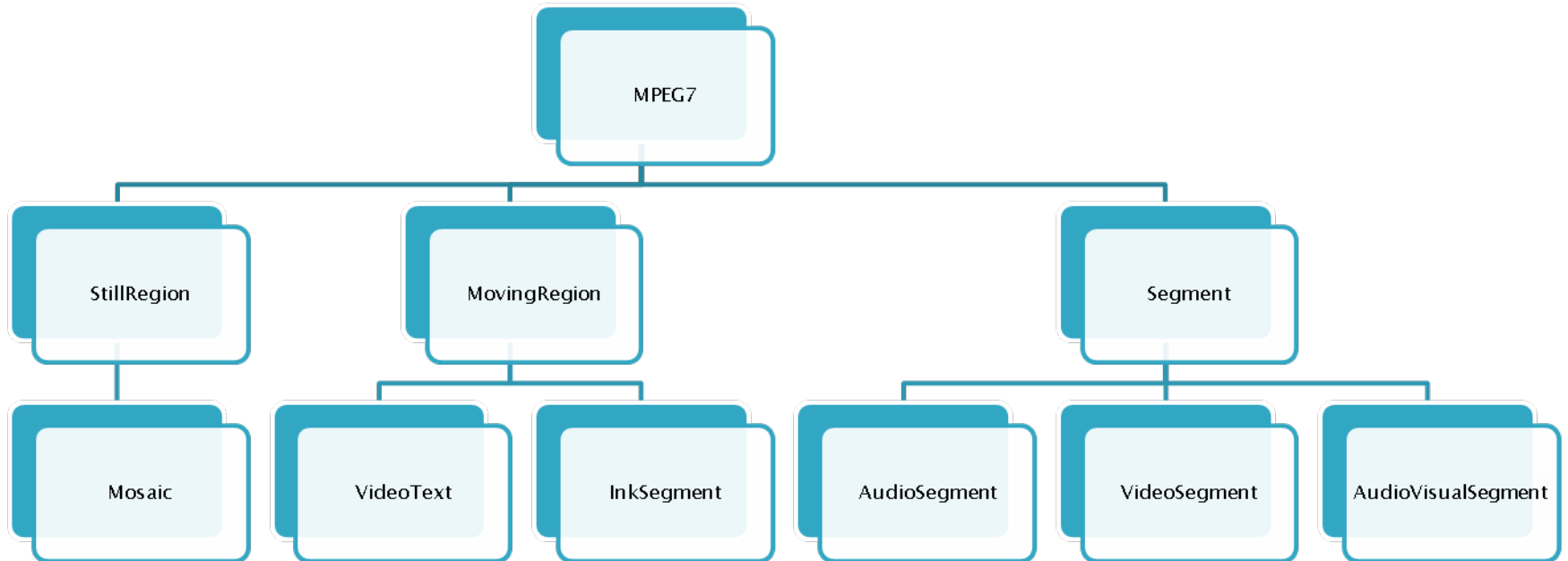


Example of MPEG-7

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<Mpeg7 xmlns="urn:mpeg:mpeg7:schema:2001"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance"
  xmlns:mpeg7="urn:mpeg:mpeg7:schema:2001"
  xsi:schemaLocation="urn:mpeg:mpeg7:schema:2001
Mpeg7-2001.xsd">
  <Description xsi:type="ContentEntityType">
    <MultimediaContent xsi:type="VideoType">
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        <CreationInformation>
          <Creation>
            <Title> Worldcup
Soccer </Title>
          </Creation>
        </CreationInformation>
        <MediaTime>
          <MediaTimePoint>T00:00:00</MediaTimePoint>
          <MediaDuration>PT1M30S</MediaDuration>
        </MediaTime>
        <VisualDescriptor
xsi:type="GoFGoPColorType" aggregation="Average">
          <ScalableColor
numOfCoeff="16" numOfBitplanesDiscarded="0">
            <Coeff> 1 2 3 4 5 6 7 8
9 0 1 2 3 4 5 6 </Coeff>
          </ScalableColor>
        </VisualDescriptor>
      </Video>
    </MultimediaContent>
  </Description>
</Mpeg7>
```



MPEG-7 Elements



Demo

- ▶ Exploring MPEG-7 Schema using Eclipse



Multimodal Data Format MMDF

»» A Digital Format for Skills



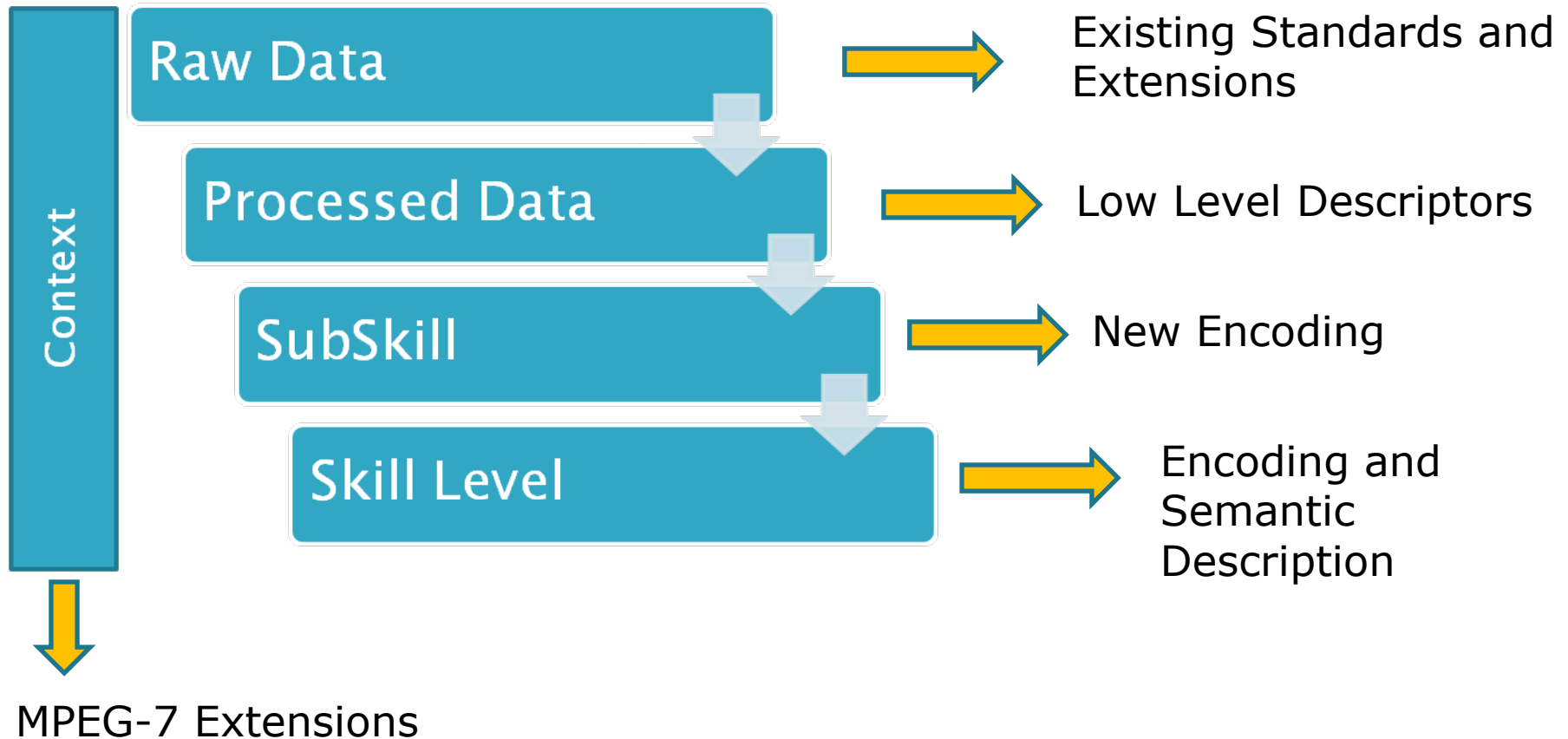
Multimodal Data Format

- ▶ **Top-Down Approach**
 - Describe Experiments, Trials, Users
 - Describe Context
- ▶ **Bottom-Up Approach**
 - Specific Encodings
 - New Algorithms
 - Encoding for Skills
- ▶ **Objective**
 - Effective format inside the project and in the Skills users community
 - Propose key elements for standardization



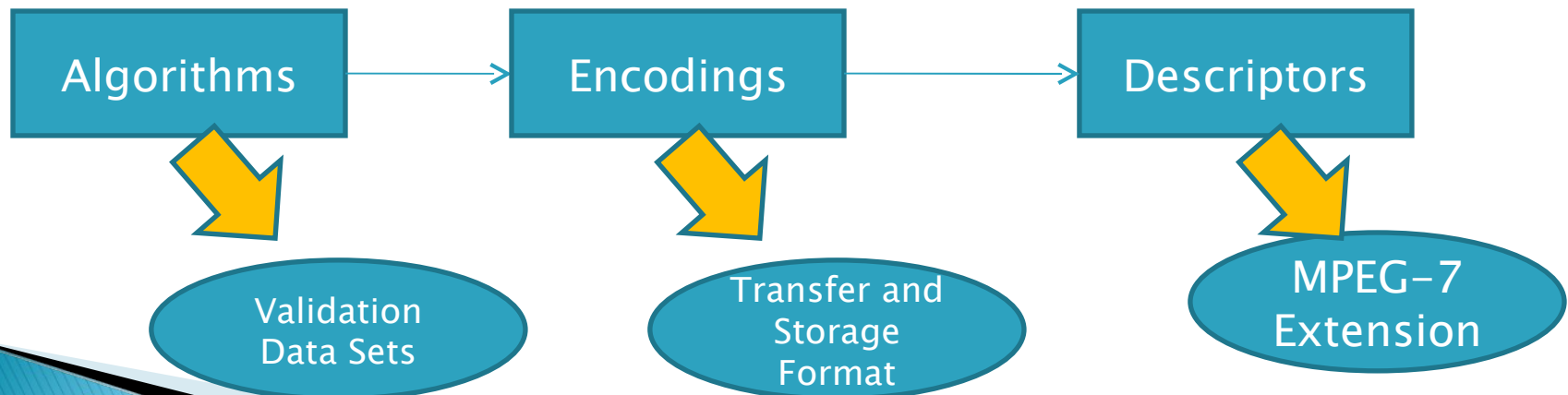
MMDF Levels

Levels of MMDF correspond to the Digital Representation



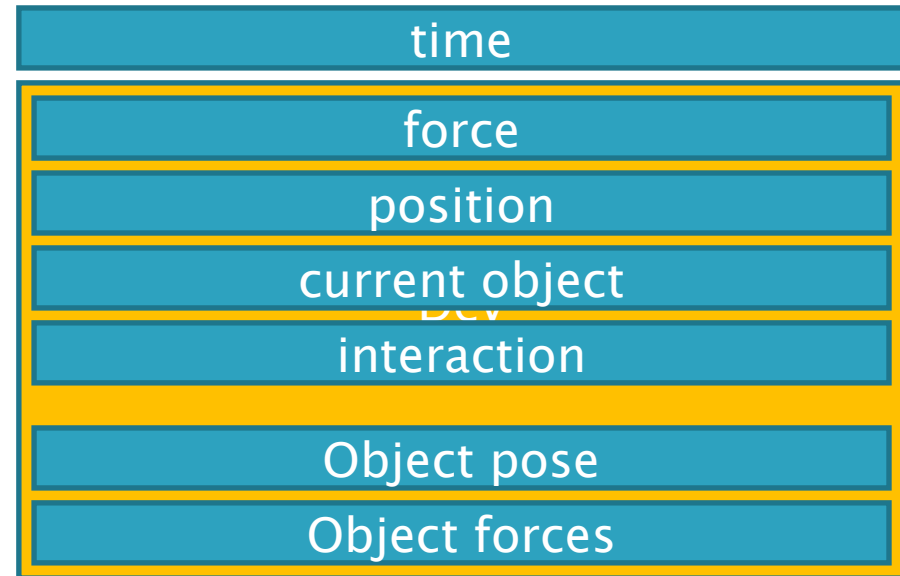
MMDF Phases

- ▶ Identify New Algorithms and Encodings
 - Encoding of the SubSkill
- ▶ Extend the generic annotation system of MPEG-7
 - Take low level data and annotate it with Skills descriptors



Haptic: Low Level Trajectory

- ▶ Haptic Interaction in a Virtual Scene
 - Description of the Scene
 - Device Type
 - Features of the Device
- ▶ Multiple Channels of information (for every end effector)
 - Time
 - Force and Position of End Effector
 - #id Object currently Interacting (if any)
 - Type of interaction with object (manipulation or touch)
 - Pose and Forces in current object
- ▶ Raw data can be analyzed for Events
 - Starting of grasping and touching
 - Stopping of the movement



Event Analysis

MMDF Getting Involved

- ▶ Contact Emanuele Ruffaldi e.ruffaldi@sssup.it
- ▶ Be part of the Skills Special Interest Group (SSIG) on <http://www.skills-ip.eu>

Thanks!



Bibliography

