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Main Descriptors of Professional Gestures, Regarding to their Intergenerational Transfer¹

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Abstract: Operational knowledge in industries is difficult to capture because of the tacit nature of gestures. The operators can be equipped with video capture devices. They can also be invited to describe the intentions of their gesture. But the bottleneck is in the gesture itself. This paper describes an experiment, which was performed at EDF (Electricité de France). Several categories of professional gestures were studied, and 10 of them were investigated. For the capture phase, the protocol aims to approach the intentions of operators, their mental models. We have produced training video material called "MAP" (Multimedia Apprenticeship Platform) for novices to learn and internalize the practice. An anthropocentric three-step methodology was applied. For all the gestures, eight descriptors were used to qualify the environment and the situation: realism, reproducibility, length, granularity, mobility, interaction, visual salience and haptic salience. A four-value scale is used on each descriptor to quantify the criticism of the gestures. Results include the perimeter of application of the MAP methodology, describing professional gestures which can be captured, formalized and transmitted. The majority of the descriptors have a moderated influence on the process, concentrating their impact on one point of the method. Only two descriptors have high-level impact on the whole process: interaction between operators and visual dimension during the realization of the professional gesture.

Keywords: Tacit knowledge, video capture, professional gesture, Multimedia Apprenticeship Platform (MAP)

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1. Introduction, context

This present work takes place in a knowledge transfer problematic, involving particularities of tacit knowledge applied to industrial context. In France, as many others European countries, important industrial progresses were accompanied by massive employment. In the 60's and 70's, we observed the emergence of technologies for high-speed trains, orbiting satellite or nuclear power plants. Many realizations by the world are testimonies of technical gestures performed by operators. Forty years later, industries as *Electricité de France* (EDF, French electrical energy producer) are now confronted to a massive retirement. By the way, this demographic transition is creating a sudden and urgent need for the transmission of tacit know-how. As made since decades, usual knowledge transfer is based on journeyman. This implicit intergenerational transfer needs one to one workers contacts and time to be achieved. Both conditions are now impossible to be satisfied, and this problem leads industries to solve differently the equation.

To consider a usual definition, the gesture is a form of non-verbal communication, implying necessarily a movement of a part of the body. There exist gestural codes in any work, in the manners of being, of behaving, of communicating, which are specific to each work environment. The topic of this paper is to approach the professional gesture as a tacit knowledge of industry but it could be approached as a part of an action, implying a communication between operator and machine.

Researches in ergonomics and work psychology on knowledge embodied in gestures impact different sectors of activities: tourism (Sauvage, 1993), automobiles and civil engineering (Chassaing, 2004), rail (Fernandez, 2001), aviation (Aubert, 2000), surgery (Tomás, 2008), etc. This literature doesn't show any consensus about terminology for work gesture analysis: Chassaing (2006) uses the terms "gesture of work," or "gestural knowledge". Clot, *and al.* (Clot, Fernandez, & Scheller, 2007) speak of gesture at work; Aubert (2000) speaks only of "gesture". However, all agree in showing the difficulties to understand the knowledge underlying professional acts by their specificity. Indeed, this knowledge belongs to a class of very special skills, those that are "*encapsulated in the action, hard to verbalize, closely related to the context*" (Leplat, 1990, 1995). We speak of knowledge embodied, that is to say, "*worn and stored by the body*" (Aubert, 2000), which involves all the senses. These are the "skill-based behavior" of Rasmussen (Rasmussen, 1983).

In the automotive sector, with assembly tasks, and in the civil engineering sector, with tasks of formwork, K. Chassaing (2004) attempts to show the organization of work gestures learned on the job, their development, structure and implementation. Partly reflected by the characteristics of professional skills, she characterizes a work gesture in four points. First, the gesture is a composition: it "*requires a sensory, cognitive and motor activity*". Second, the gesture is invested: it "*is intentional and is oriented toward different goals: to the system, to itself, and to others*". Third, the gesture is situated, "*the work activity [...] is in a situation*". Last, the gesture is built: it "*is the product of a history, of a past, and continues to be expanded.*"

The purpose of this research is focused on the capture and transfer of professional knowledge, and not on the study of gesture as such. For this, we use theories of work analysis, but from a quite different perspective from Clot *et al.* Indeed, our observations and analysis focused not on the overall activity of an operator on his job, but on specific segments of his activity selected by the organization and based on: 1) their criticality from the perspective of the organization, and 2) the expertise involved from the operator. These segments are called "professional gestures" by the organization EDF. What is called in common language an operation (e.g. maintenance), a maneuver (e.g. a seal change) or broadly an activity, is called "gesture" by the training professionals because of the strong physical, manual component that covers the job of operators in nuclear power plants.

From our perspective, we define the "professional gesture" as the outward manifestation of an activity segment, carrying expert skills and guided by motives and goals. The notion of segment implies that the duration of this activity is limited in time. Following Russian Activity Theory (Leontiev, 1978; Nosulenko & Rabardel, 2007; Rubinstein, 1940) which is our main intellectual framework, studied gestures are intentional, following a motive, and are determined by a set of goals achieved through actions.

Our work investigates the use of digital video and activity elicitation to give a guideline and operational tools for the capture of knowledge embodied in professional gestures. The operators are equipped with video capture devices. They are also invited to describe the intentions (the goals) of their gesture. But the main problem for this situation is to understand the gesture itself and to know if the gesture can be captured and how. How can it be characterized? Which aspects of the gesture are determinant for a good outside perception? How can we access to the gesture's cognition? What is the tacit part in a professional gesture?

2. Material and method

This section presents a brief synthesis of the Multimedia Apprenticeship Platform (MAP) construction methodology (Le Bellu, Lahlou, & Nosulenko, 2010) and an overview of collected gestures. The MAP is a tool that allows novices to represent themselves a mental model of the gesture, hierarchically and sequentially structured. It illustrates the gesture in details, with the help of video sequences.

2.1. To capture

Agreement step

A semi-directive interview brings together the analyst in charge of the MAP creation and an operator. The hierarchy has identified the operator and appointed him for his skills and expertise.

This first stage addresses three objectives: 1) inform the operator of the process to which he/she is committing; 2) arrive at a common mental model of the gesture by asking the operator to mention his/her goals, and 3) collect information that will enable to plan the capture (what, where, who, when).

We present below a set of ten professional gestures selected by the EDF training branch for their rare (only a few times performed throughout a career and mastered by a handful of people) and/or critical (i.e. involving safety, security and/or performance of the company) features. This gestures corpus constitutes our work material for this study.



G1: Remote operation of a tap

The tap is controlled via a "button box" that the operator connects to the system after have made the control power cell operational.



G2: Manual setting of a tap

The operator activates a tap high located and controls the adjustments effects on a high dial located at this level.



G3: Diagnosis of an electrovalve malfunction

By manually activating the valve, the operator identifies adjustments to be made.



G4: Diagnosis of a valve failure

Faced with a valve failure case, the operator compares the current valve with the representation of a correct one.



G5: Control of a valve tightness

After a maintenance operation, the operator controls pressure and parallelism of a valve tightness made by other operators.



G6: Condenser closure

Seal installation and valve closing by calibration and checking of the position of a large condenser horizontally installed.



G7: Consignment of a pump

The operator isolates and drains pumps containing superheated water. A first operator identifies a range of key points and organs to be “consignmented” on a map. A second operator does operations and reports to the first through an informal dialogue phase.



G8: Rond of safety operator

Check of a functioning site.



G9: Tightening of a bolted ensemble

Seal changing and bolted ensemble restoration on a valve.



G10: Chargers switching

The operator switches chargers on a 380V electrical board. Two different operators have performed this gesture.

Video recording

The operator wears a subjective camera (subcam) (Lahlou, 1998, 2011) – focused on the operator's activity from his own point of view, and another external camera filming the context of the scene – a hand-held camera and/or a camera on a support. For the purpose of this research, a special subcam was designed to be embedded on the protective helmet of operators working in factory environments (Figure 1).

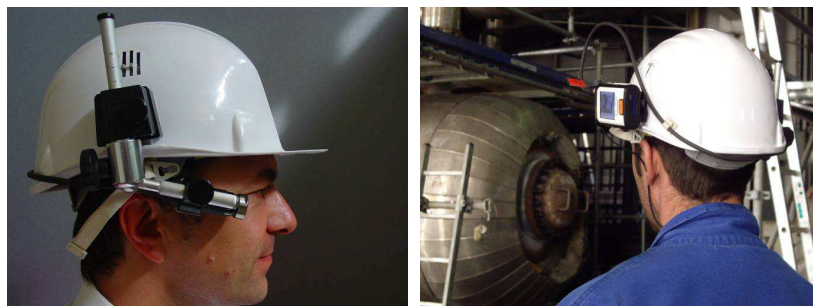


Figure 1: The “hard hat” worksite version of the subcam.

There are three moments in the gesture capture step.

1. The just-before time corresponds to the mental preparation. The analyst asks the operator to mimic or perform the gesture. It gives the operator confidence and enables him/her to specify his/her mental model by putting what he/she does into words.

2. The next moment is the recording one. The operator must perform the real actions of its gesture in the most natural way possible. In the specific case of a collaborative gesture, each operator wears a subcam. The operator is asked to think aloud, using a goal-directed verbalization protocol (Le Bellu, Lahlou, & Le Blanc, 2009) to collect the operator's intentions. This is done while accompanying each of the goals with explanations answering the following questions: For what reason (why) and in what manner (how) is the gesture performed? *“The operator is freely allowed to consider what is worthy of comment, in regard to the level of sophistication in the breakdown of his/her activity, as well as the moments in time where a specific action begins or ends.”* (Le Bellu et al. 2009). Our experiments show that a goal-directed verbalization protocol aims to externalize tacit knowledge and access to the gesture's cognition. With the mental preparation just before, the operator has engaged his knowledge and has prepared his speech. By the way, the inevitable disruption of the gesture is reduced (Ericsson & Simon, 1979, 1984).

3. The just-after video-recording time is dedicated to an “on the spot” debriefing with the operator. Did he run into any problems? What were the specific components of this situation? What does stay the same, what doesn’t usually change? By this questions, the analyst tries to access to the intra-individual diversity of the gesture.

2.2. To analyze and to formalize

Analysis: to study data

One analysis of the gesture based on activity theory (Leontiev, 1978; Rubinstein, 1940) and perceived quality theory (Nosulenko, 1988; Nosulenko & Samoylenko, 2001, 2009) is performed in delayed time of the capture. Firstly, the recorded videos are evaluated considering their quality, quantity of information, correspondence to the capture protocol, etc. Secondly, the objective is to plan and to edit a version of a whole video of the gesture performance that puts together subjective and contextual points of view. This video-making must preserve a maximum of information about the gesture to be used as a guideline or the operator’s commentary during the next step.

For this analysis work, the analyst uses videos and others materials collected during previous steps. Thus, the analysis leads to develop initial hypotheses about the importance of the different operations and the intentional structure of the gesture according to activity’s components: goals, sub-goals, tasks and operations (Leontiev, 1978; Rubinstein, 1940).

Self-confrontation interview: accessing to the subject’s subjective experience

The self-confrontation interview method (Theureau, 1992; Von Cranach, 1982) re-immerses the operator in his own activity by confronting him with the recorded gesture. The explanation interview (Vermeresch, 1994, 2003), the crossed self-confrontation techniques (Clot, Faïta, Fernandez, & Scheller, 2001; Mollo & Falzon, 2004) and the re-situ interview (Rix & Biache, 2004) are variations based on the same principle. The variant we are using shares with Cranach’s method the fact of resting on the activity theory. Considering our previous practices of different situations (Lahlou, 2010; Nosulenko, Barabanshikov, Brushlinsky, & Rabardel, 2005; Nosulenko & Samoylenko, 2009), we tend to be a little bit flexible in the formalization of our protocols. The main point is to collect reliable elements to be able to reconstruct the activity.

The self-confrontation interview can be made not only with the mobilised operator, but also with another specialist of the considered gesture. This latter modus operandi has the advantage of more easily identifying the components of the knowledge: acquired expertise, lack of experience, practice. Verbal data recorded during that interview enable to emphasise components of the activity within the meaning of Russian activity theory.

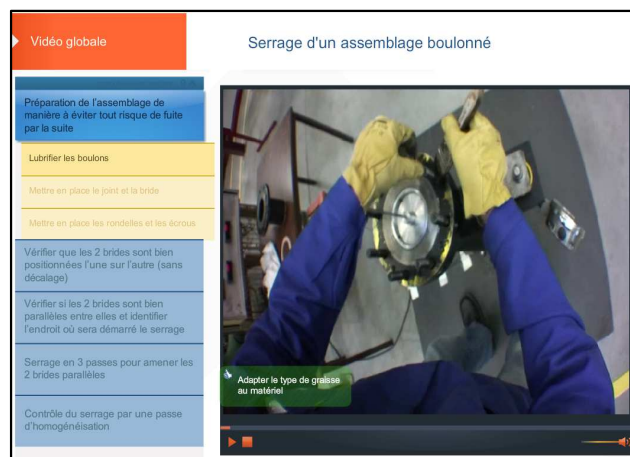


Figure 2: G9 gesture MAP printscreen

Further analysis, final video-making and building of the MAP

Based on data collected during the self-confrontation interview, the analyst changes the first video to be the nearest of the operator's gesture mental model. He can add/delete video parts, add a voiceover, exploit the self-confrontation's soundtrack, add/delete text annotations on the video, adds/removes icons, etc. This further analysis gives rise to a Multimedia Apprenticeship Platform (MAP) is a mode of synthetic representation, which aims to present the most important components of the captured gesture according to the operator's point of view (Figure 2).

2.3. To validate and to use: final validation of the MAP resource

The MAP undergoes three levels of validation:

- A business validation: to check if the MAP is consistent with the considered gesture. The operator begins this validation just after the capture, continues during self-confrontation and ends at this stage;
- An institutional and hierarchical validation: to verify the compliance of the gesture in relation to the institutional repository;
- An educational validation: to validate the relevance of educational content carried by the MAP.

After this validation process, trainers of the company's training department can use the MAP in their training sessions (Figure 3).



Figure 3: use of the MAP during training session

3. Results

3.1. Characterize a professional gesture: a proposition of classification in eight points

All of the above professional gestures were included in a process of MAP building. For some of them the progression of the process was easy. It was more difficult for others. Considering the gesture itself, we distinguish eight characteristics, giving pieces of information for the "MAPpability" of gestures. This diagnosis leads to a classification of professional gestures in eight points. Each feature has four possible modalities. A bold font is used to indicate terms that were not encountered in our corpus of gestures.

A. *Realism of the situation*

This is the degree of spontaneity of the capture situation. At one pole are the most artificial situations: the action is performed but the result does not occur (e.g. training exercises); at the other pole, are the most natural situations (e.g. performance of a maintenance gesture in a working power plant).

- **Level 1:** simulation of the only highlighted facts related to objects handled outside of the workplace. At this level, the context is only symbolized.

- Level 2: the situation is re-created. The environment and work situation are simulated outside the natural workplace.
- Level 3: the real situation is prepared. The gesture is produced on the real workplace. Consequences are expected, and can therefore be anticipated.
- Level 4: this is the real life mode. The capture is made *on-the-fly*, not provided for.

B. Reproducibility-flexibility

The more there is a decision-making part in the gesture, the more the operator has latitude in the choice of the procedure adaptation. This raises the problem of capture: can we capture a gesture that is truly "iconic"?

- Level 1: the gesture is made only once; it's enough to obtain the "example".
- Level 2: you have to do the same gesture several times to identify the example.
- **Level 3:** you must set several conditions to understand the mental model of the gesture.
- Level 4: however multiple instances of the gesture are performed, it can still happen something different. Each case is unique.

The degree of flexibility available to the operator can give some answers. For example, in the case of a monitoring (G8), there is a procedure to apply (e.g. every day, the scaffolding must be checked), but his flexibility is important. Operator organizes his course as he wishes. Another example is the G7 gesture in which a failure diagnosis is made following a leakage problem. At the opposite, the more the environment is controlled (e.g. G2: a procedure application), the closer we approach ordinary daylife gestures. Thus, more a flexibility exists, the less the gesture is exactly reproduced.

C. Length

A lot of questions exist of the relationship between perceived time and real time. Our observations show that the acceptable length of a film is about eight minutes to obtain a correct usable material. The length will be accentuated by the verbalization. Beyond, the perceived duration by the end-user apprentice is too long. This means that there would be levels of operability that pass through the cutting of a gesture in short sequences of less than ten minutes.

- **Level 1:** cases of very short gestures (in the order of seconds).
- Level 2: cases of short gestures (in order of minutes).
- Level 3: gestures of about ten minutes. Despite the reproducibility of the gesture, we hesitate to repeat it, due to the time of capture.
- Level 4: gestures that we don't repeat the capture: several decades of minutes.

Perceived time is not only linked to real time, it includes perception of physical or intellectual effort. The longer the duration of the gesture is, the more it affects the ability to concentrate.

D. Granularity-accuracy

This is a notion of precision in gesture: rather thin ("fingertip") or rather wide (large arm movements). We notice that it is possible that the visual acuity of the observer plays a role in granularity definition.

- **Level 1: very thin.**
- Level 2: thin.
- Level 3: wide.
- Level 4: very wide.

E. Movements-mobility in gesture

The mobility in the gesture requires sometimes body movements. It depends on the area, and if the involved system is or not distributed in space.

- Level 1: no displacement. A single confined space.
- Level 2: multiple cameras/viewpoints are used to cover several fixed places. Example: in the

G2 gesture, movement (in height) is sustained by the operator. He has no choice; it is a necessary action for the pursuit and realization of his gesture.

- Level 3: a mosaic of places, with a mobile camera to track the movements. The movement is a part of the gesture and it's something going on during this movement.
- Level 4: the gesture is a displacement. We must follow up. For example, in the gesture of monitoring (G8).

F. Collaboration and verbal interactions

The problem of communication and verbal interactions during the gesture is generally correlated with the inter-operator collaboration; this is what we call collaborative gesture.

- Level 1: no verbal interaction.
- Level 2: from time to time interactions. The interaction must be anticipated; it is expected in the process. Example: a phone call to report the situation or to make inquiries. By the way, some verbal interactions may be present in a solitary gesture.
- Level 3: in situ and frequent interactions. The conversation is a part of the gesture and involves several operators in performing the gesture. The gesture is collaborative.
- Level 4: interactions strongly linked to the task. The gesture is conversation.

G. Visual salience

This characteristic indicates a visual component in the gesture realization.

- **Level 1:** the gesture may be performed blind (e.g. as an answer at the phone).
- Level 2: some visual cues are necessary.
- Level 3: a visual control is required for the gesture performing.
- Level 4: a monitoring activity.

H. Haptic salience

This characteristic indicates an haptic component in the gesture realization.

- Level 1: the gesture can take place hands in pockets.
- **Level 2:** the gesture only requires a few tactile landmarks.
- Level 3: touch is necessary for the gesture.
- Level 4: permanent touch.

3.2. Application scope of the capture method

Figure 4 provides an overview of the studied gestures profiles (G1-G10). It shows that most cases were covered by the experiments. On the 32 possible items (eight characteristics, each with four terms), six have not been encountered in the studied corpus. These are the terms notified in bold in the previous section. We have highlighted them by black circles in Figure 4.

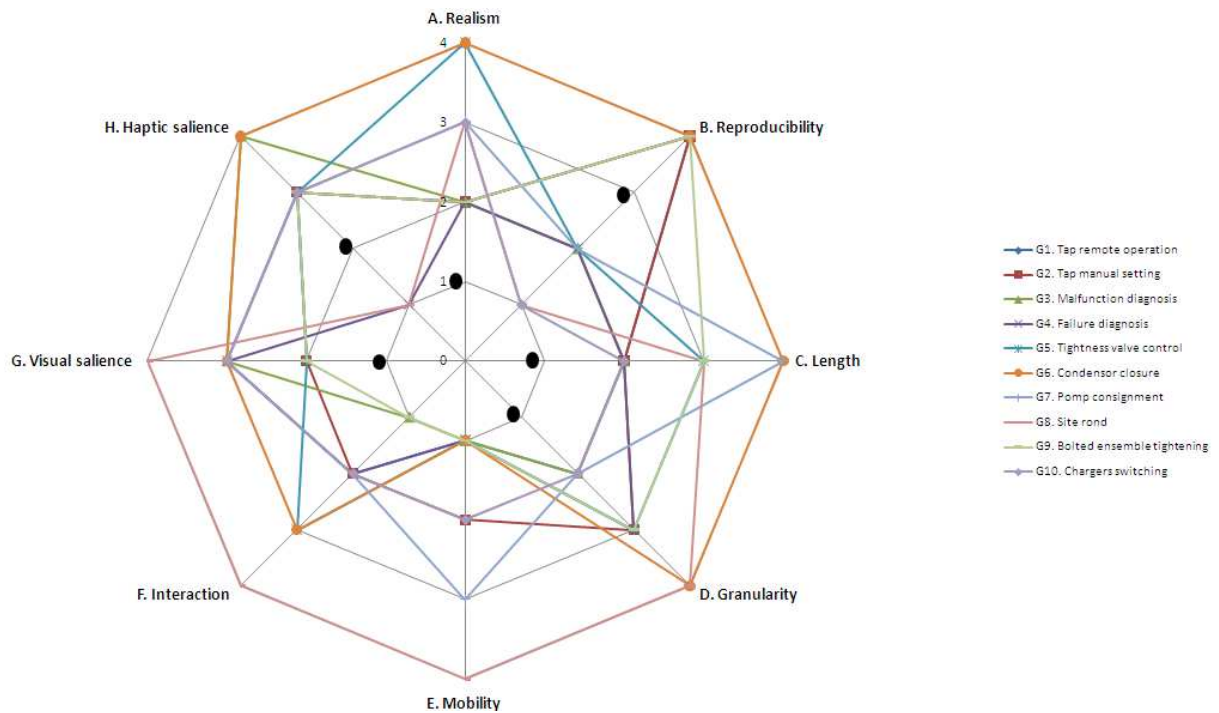
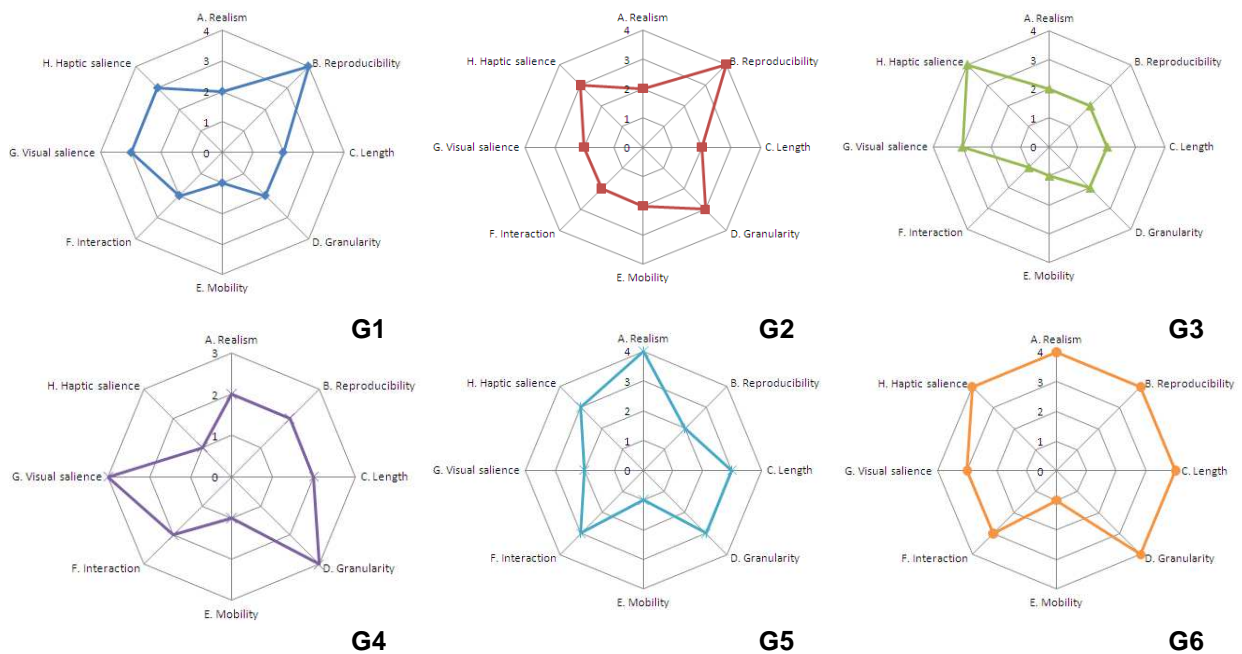


Figure 4 : Overview of the captured gestures corpus

Gestures with profiles located as in the periphery of the diagram, such as G6 and G8, correspond to "complex gestures"; the MAP is difficult to obtain. Those located further inside, such as G1, G2 and G10 are the most MAPpable: these are "simple gestures". Between, it is recommended to dwell on the reading of characteristics. Figure 5 describes each of the profiles.



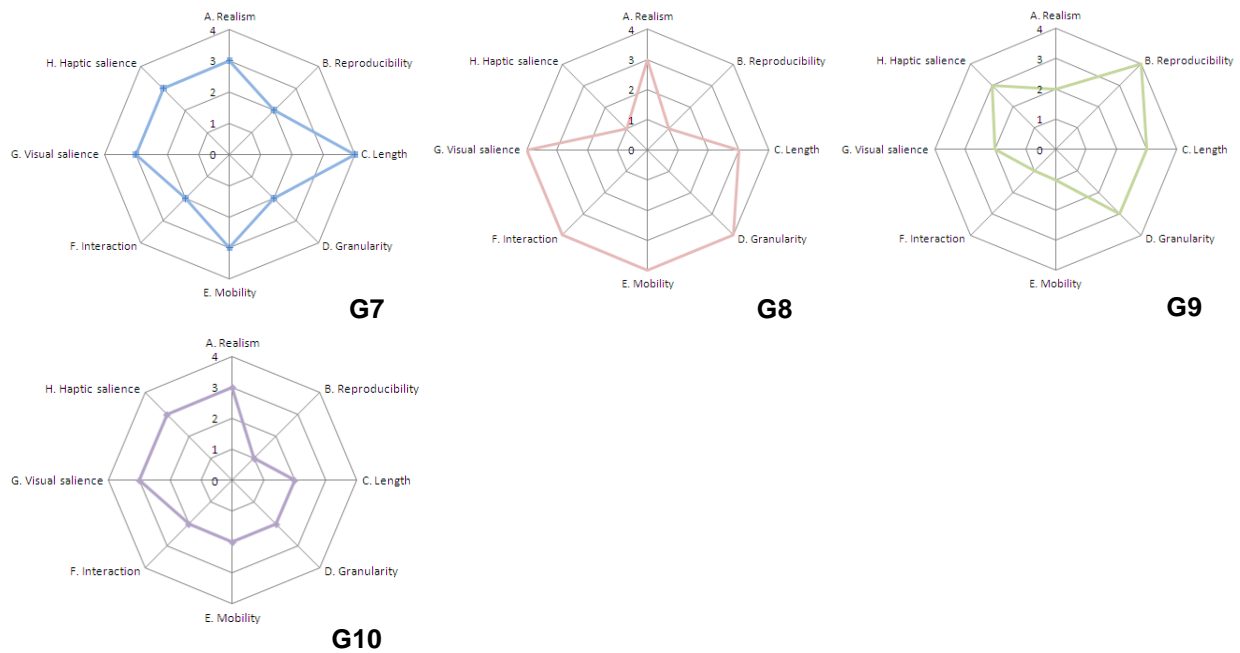


Figure 5 : Profiles of each captured gesture

4. Discussion, conclusion

Which limits for capturing and transmit professional gestures? This question asks whether all professional gestures can be captured, analyzed, and formalized to be transferred in the form of a MAP. Our experiments distinguish between simple and complex gestures.

In the presented work, each of the ten withheld gestures was studied. All of them provide a part of tacit knowledge. The eight proposed descriptors give a pertinent way to approach this tacit part. Intuitively, gestures with small values on their descriptors are easy to formalize, with a “controlled” tacit part. Then the profile of each gesture, as shown in figure 5, is a rapid clue to synthesize the tacit component of a gesture.

We have also put forward that descriptors do not all have the same importance. Items as collaborative, decision-making and motor/visual characteristics are involved in determining the complexity of a gesture. They are present in the descriptors F (verbal interactions) and G (visual component of a gesture). High values for these two descriptors imply difficulties to capture, to analyze and to validate the MAP (the three steps of the methodology). High values on other descriptors lead to localized difficulties during the methodology application: during the capture for descriptors A (realism), D (granularity) and E (mobility), mainly for the quality of the recorded video; during the analyze for descriptor B (reproducibility); or during the video edition for descriptor C (length). Descriptor H (haptic component) is well apprehended due to the position of the camera on the head of the operator.

The visual component of a gesture (descriptor G, i.e. the fact that the operator needs his eyes to perform the gesture) is present with a high value in the majority of gestures: level 3 for G1, G3, G4, G6, G7 and G10; and level 4 for G8. But only G8 leads to real difficulties to formalize and to analyse; to an extent G6 also gives us some problems. This is due to the fact that G8 has a small value for haptic component (level 1) whereas other gestures have a higher level (3 or 4). In fact the ratio Descriptor G/Descriptor H seems to be more pertinent than simple values of descriptors.

Nevertheless, considering this ratio is not enough. G4 has the same big value for ratio G/H, without the same problems to formalize. The area of all descriptors must be taken into account. While we have small values as 16 to 19 for G1, G2, G3, G4, G9 and G10, this area grows to 22 for G7, 24 for G8 and 27 for G6.

Due to the interactions between operators (G6 and G7) or interactions with other people (G8), collaborative gestures lead also to difficulties for the formalization step. This collaboration must be

synchronous (as for G6 with two operators working in the same time on the same material) or takes place during key times (as for G7 with two operators following individual specific goals). Our work shows that a special attention must be considered on visual component (with G/H ratio); collaborative form and global descriptor area. These are three important clues to transfer tacit knowledge from operators to novices.

This repository of professional gestures could be used as a tool to classify other gestures, compare them to encountered cases, and thus ensure they can be transferred. Then, understanding their criticality leads to adapt the method and anticipate ahead difficulties.

This work on the capture of many professional gestures makes the link with the tacit knowledge and its problems of capture and transmission. Considering operational acts, we obtain an approach of expertise. The limitations of our approach meet the limits of the distanced course with respect to the journeyman approach. Although this work remains in terms of observation, the complement given by the perceived quality theory enables to put forward intentions of the operator by verbalization techniques.

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