Computer Support for Normative EMG Data Determination*

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Abstract. In the paper we discuss an approach to computer support of collecting EMG data, for the purpose of national normative EMG data determination. To find values that are as representative as possible (to become a true standard), we proposed to have several laboratories across the country collecting the data. We describe representation of both EMG data request and response, which serve as a main vehicle for communication between EMG laboratories involved in data collecting. Based on the proposed representation, we developed two software prototypes: Normative Data Application Client and Normative Data Application Manager, which support collection and management of measured EMG data. The process of normative EMG data determination and continuous monitoring of their adequacy is more effective with support of these tools.

1 Introduction

Normative data are useful in the process of developing electromyography (EMG) standard examination procedures, analyses and evaluation. Normative data enable EMG practitioners to compare clinical data of patients to those of healthy persons. When normative data are available, risks of improper examination interpretation decrease.

Currently, normative EMG data are not so common and only relatively a few laboratories have them available. We therefore aim to support collecting measured EMG data suitable for normative EMG data determination. Medical experience shows, that it is reasonable to assume that there exist EMG clinical values, which can be considered as standard across a population in a region as

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wide as a country like Slovakia due to relatively similar conditions influencing them [7]. Therefore, several EMG data sets may be collected to provide representative data for a region or a country. For each of them, an appropriate sampling of the population requires examining many subjects evenly distributed throughout the region. Among several EMG laboratories involved in collecting measured values, one should assume a coordinating role in their creation, distribution, evaluation, and maintenance.

Development of normative data is a long-term and demanding process. In this process advanced information technology can help significantly. As a part of the EMG-net project [3], we have proposed and developed set of software tools that are designed to support the development of normative EMG data. The ultimate goal in this part of the project is to have electronically available normative EMG data that would enhance the quality of EMG-based diagnostics supported by the software tools.

In this paper, we present our concept of computer supported collecting of EMG data, which would serve for normative EMG data determination. We describe the proposed way of coordinating the collection of measured EMG data in detail. We also envisage two software applications named NoDAC (Normative Data Application Client) and NoDAM (Normative Data Application Manager) [1, 6] both making full use of proposed representation of measured EMG values. Finally, we discuss our results and give some proposals for future development.

2 Conceptual Model for Collecting EMG Data

To find values that are as representative as possible (to become a true standard), we proposed to have several laboratories across the country collecting the data (see also Figure 1). They are distributed throughout the territory, where the EMG data are collected. Local laboratories participate mainly on the following tasks:

- measuring the EMG values on healthy volunteers,
- passing on the recorded EMG values to the coordinating laboratory.

The measurements are coordinated by the EMG laboratory that should

- issue requests for EMG measurements to local laboratories,
- accumulate, store and monitor the measured EMG values provided by local laboratories.

The main role of the coordinating laboratory is to monitor, store and partially evaluate collected EMG data, in order to be able determine appropriate normative data from recorded values. However, all laboratories should closely collaborate on formulating of the requests. Well-defined requests strongly influence results of a process of EMG data collecting, because each laboratory can have specific possibilities according the measured values (mainly in respect with healthy volunteers).

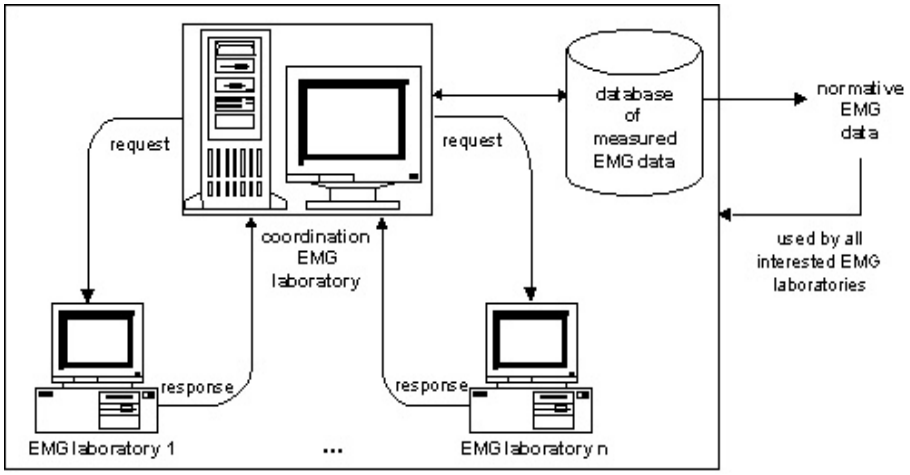

Fig. 1. Conceptual model for collecting normative EMG data.

The requests distributed from the coordinating laboratory to the local laboratories contain information about required EMG examinations (the type of the examination technique, the applied anatomical structure, the list of parameters to be recorded) as well as requirements on a subject being examined (sex, age, temperature, etc.). Additional information, which allows standardisation of the examination process, in the form of a comment or a picture to each examination request may be attached.

The physician in a local EMG laboratory receives a request containing all the above-described information. His/her main responsibility is to examine a healthy person of required age and sex that satisfies the examination conditions as agreed.

3 Request and Response Representation

Local laboratories as well as the coordinating laboratory have to collaborate on common tasks. As already stated, their roles in collaboration differ significantly. We therefore adopted a strategy of developing two distinct software tools each supporting the respective roles. They both will be described later in this paper. At the same time, the necessary communication between the software tools had to be established. For these purposes, we proposed the structural representation of requests and responses in the eXtensible Markup Language (XML) [2]. Requests are in the form of files sent from the coordinating laboratory to local EMG laboratories that return their response back to the coordinating laboratory (see Figure 1).

XML was chosen because of its facility to describe the content of structured data flexibly and across multiple platforms. The readability of XML text files

as well as the availability of software tools supporting XML parsing was equally significant.

The structure of request and response files is very similar. The main difference is that request files do not contain values of particular parameters. These will be measured and automatically included in the response file. Design of request and response files was motivated by Communication Protocol EPC/ECCO 3.2 for storing of EMG data [5, 4].

Each request and response file consists of two sections:

- `generalInfo`: general information for the record keeping,
- `requestGroup`: all information relevant to one test.

As depicted in UML notation (see Figure 2), the request group may be included several times in a request/response file. This allows to group several tests into one unit so that they may be sent as one request. Each response should group tests that may be performed in one EMG session, for example those with common examination conditions.

In Data Type Definition (DTD), the structure of request/response file is specified as `<!ELEMENT requestDocument (generalInfo, requestGroup+ )>`.

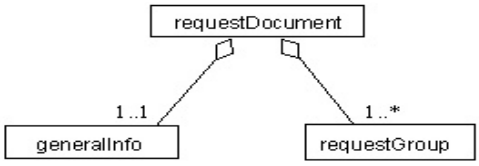

Fig. 2. The structure of request/response file.

Each request group is composed of several subsections (see Figure 3) that enable to express examination conditions (`requestCondition`), personal information about the subject being examined (`requestPersonInformation`), instructions for the test (`requestInstruction`), identification of the type of the examination technique and the applied anatomical structure (`requestHierarchy`), and the parameters (requestParameters). All subsections are in a one to one relation to `requestGroup`, but they may contain several items. Items are not statically predefined and may be readily adapted to its specific name, value, and other attributes as required.

The subsection describing parameters may contain any number of items named `param` each with attributes as defined in the relevant part of the DTD:

```
<!ATTLIST param
     id       CDATA #REQUIRED
     name     CDATA #REQUIRED
     value    CDATA #REQUIRED
     unitName CDATA #REQUIRED
     isMandatory (1|0) #REQUIRED>
```

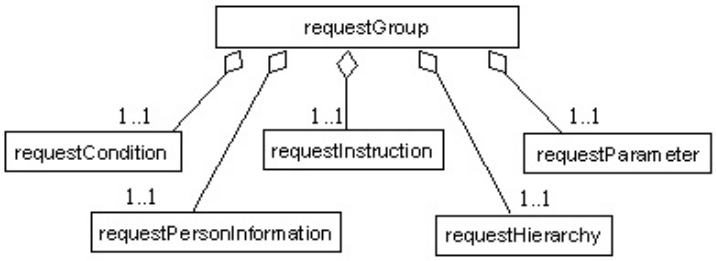

Fig. 3. The structure of each examination included in request/response file.

This approach allows defining a specific set of parameters for each examination technique. As an example, we show a fragment of parameters definition for *N. ulnaris* examined by antidromic sensory nerve studies:

```
<requestParameters>
     <param id="34" name="Conduction velocity"
                    unitName="m/s" value="" isMandatory="1"/>
     <param id="36" name="Area ratio"
                    unitName="%" value="" isMandatory="0"/>
     <param id="25" name="Distal latency"
                    unitName="ms" value="" isMandatory="0"/>
</requestParameters>
```

Using XML files as the exchange format between the coordinating laboratory and the local EMG laboratory has several advantages:

- the content of the document is dynamic, depending on the actual anatomical structures that are examined and used examination techniques,
- the content of the document is self-describing because of the text-based nature of XML files,
- the request and response transmission is highly error-free because its non-binary character,
- the data are "open" for third party software processing.

4 NoDaM (Normative Data Application Manager)

Management of collecting the requested EMG data is the most preferred task in current phase because in order to be able to determine the normative EMG data, there must be a sufficient amount of measured data available. We therefore preferably concentrated on solving the request's distribution and response's gathering. However, we took the future processing of data into consideration and designed a relational database for collected measured data. Our relational data model is capable of storing measured data and gives also good prospects for any further processing on recorded values. We are convinced that the chosen approach allows determination of correct and liable normative data.

For the coordinating EMG laboratory, we designed and developed a prototype software tool called NoDaM (Normative Data Application Manager). Its primarily functions are

- to produce the correct XML request files according to user's requirements,
- to process the data from the XML response file and transform them to internal relational database.

NoDAM allows to insert data from response files (extension `.rsf`) that are sent from local laboratories. In a moment when new data are inserted into the internal database, the coordinator may decide not to include those data into the database. The reason may be that the values sent from a local laboratory may be not consistent. All data stored in database may be listed according to the filtering criteria. Filtering is useful with respect to the great amount of possible data and currently corresponds to known anatomical structures (see also Figure 4).

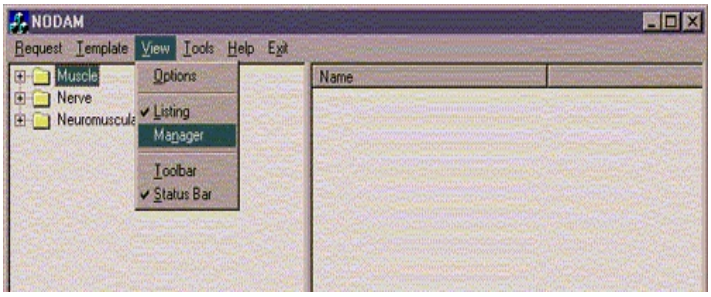

Fig. 4. Different views in NoDaM.

NoDAM helps produce request files (extension `.rqf`). When a new request is formed, the user has to specify the general requirements about examination conditions and examined subject first. Then, the examination technique, the applied anatomical structure and the required parameters are to be selected for each examination. A new request does not have to be formed at once – its actual state is internally stored in a so-called container. When demanded, `.rqf` request files are generated from the container automatically.

5 NoDAC (Normative Data Application Client)

NoDAC, the software tool, allows the examiner to record the values of EMG parameters. It lets him/her know the requirements from the coordinating laboratory and sent measured data back. In the EMG examination session, information about the examined person and the examiner has to be supplied as well. When the examination session is completed, NoDAC generates the XML response file

(extension `.rsf`), which contains the measured data as well as all additional information related to the examination.

Our main goal was to keep this tool as simple as possible by providing the minimal functionality actually needed. We therefore designed NoDAC as a dynamic form configured by the XML request file. Only those parameters specified in the obtained request file are displayed in the form (see Figure 5). The other ones, non-relevant or not required, have not to be considered. As shown in Figure 5, beside the parameters to be recorded the examiner knows also general information about measurement, relevant constraints and instructions for measurement. If available, a picture may be previewed as well.

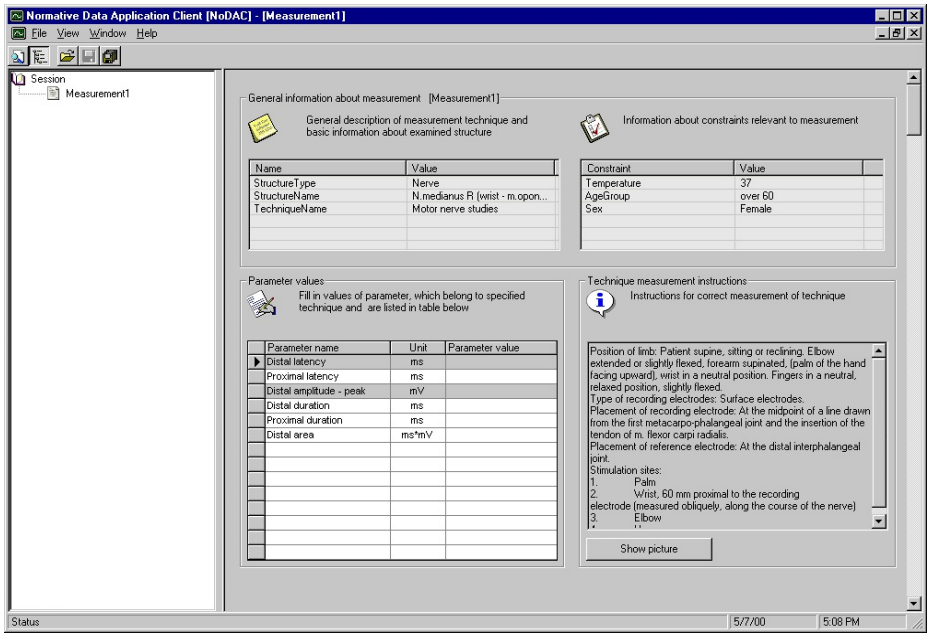

Fig. 5. NoDAC measurement values screen.

In each EMG laboratory, the physician has an opportunity to see all up-to-now received examination requests. The request files are split to the level of individual examinations. The common information included in the request file is attached to each particular examination. A physician in the EMG laboratory may select from the given list of examinations those that (s)he wants to accomplish and set up his/her EMG examination session. All measurements included in such session are listed in the left side of the user interface (see Figure 5). We preferred to atomise request files in the EMG laboratory, because it gives the examiner freedom by making up the actual EMG examination session and

avoids the situation when (s)he would be not able to perform all tests in one examination session for some reasons.

Since a long-term collection with as many data as possible is assumed, there may be possibly hundreds of requirements sent from the coordinating laboratory. We therefore proposed a simple management of examinations. First of all, those examinations that have been already performed are distinguished from those that have been not. Also, searching among examinations is possible. The examiner may restrict listed examinations according to some examination criteria. We emphasise that the search criteria as well as the possible values of the criteria are derived from current requests dynamically so that the examiner is not burdened by non-relevant information.

6 Conclusions and Future Work

The work presented in this paper is aimed towards EMG standardisation by setting up normative EMG data. Our concept of computer supported collection of measured EMG data enables to establish the normative data with less demand, in a shorter period of time, and concurrently for several nations or regions. Through the active collaboration of EMG laboratories, the knowledge and competence in the EMG domain is disseminated and further enhanced.

We have proposed the communication between the EMG laboratories, which is based on well-formed request and response files, specified in the XML format. The structure of request/response is flexible so that new types of entities may be easily integrated. Based on this representation, we have designed and implemented NoDAC and NoDAM, two prototypes of software tools supporting collection of measured EMG data. Both software tools were designed with respect to the needs of Slovak EMG laboratory. Some design decisions such as the possibility of off-line communication between the coordinating laboratory and the local laboratories were highly influenced by the specific circumstances in Slovakia. However, we are convinced that the main ideas encompassed in our tools are applicable to collecting the EMG data for normative EMG data determination in other countries as well.

In the future, several distinct improvements are possible. NoDAM should be extended by a statistical module that would calculate the normative data from those measured and stored in the database. Also, management of sending and receiving request files should be further elaborated. Another important issue is to incorporate the relational database of normative EMG values into other EMG software tools that might be significantly improved by making the use of normative EMG data.

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