HOW TO EXERCISE COMPLEX MEASUREMENTS

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Abstract: This contribution deals with some remarks and hints that could help in the solution of the common question how to conceive and arrange the laboratory exercises on the measurement tasks that are too complex that there is not enough time to introduce, comprehensively explain and practice during laboratory exercise. As an example of such task, the measurement of voice transmission quality of service (VTQoS) in modern telecommunication network (e.g. GSM) is chosen.

1 INTRODUCTION

Contemporary industrial measurements are far away from simple tasks when the amount of the measured quantity is transformed by almost linear or at least monotonic conversion into electrical signal that is displayed using suitable analogue or digital meter. Most of today's measurement tasks cover acquisition and processing of many input quantities that creates the result by linear or non-linear combination. Moreover, these quantities are usually not directly accessible and have to be measured indirectly. Sometimes it is necessary to monitor not only actual state of particular quantities but also their history. Algorithms that are being used for data post-processing are more and more often not purely straight-forward but contains blocks that introduce modern approaches of signal processing like fuzzy logic, iterative processes or predictive algorithms. Nevertheless, as exact and reliable error analysis as possible and guaranteed stability and accuracy are required for the output result.

The more complex the measurement tasks are, the more difficult is to design an effective laboratory exercise on them. There is not enough time during one exercise to introduce, in detail describe and explain, and finally measure and exercise. On the other hand, many principles and methods are to be covered by one subject that means only few or even none of tasks can be distributed over more than one exercise.

There are many approaches to the solution of this problem. First, two very popular but not too successful ways are listed. As an example of complex measurement task, the problem of intrusive measurement of voice transmission quality of service in modern mobile telecommunication network will be used.

2 QOS MEASUREMENT – COMPLEX MEASUREMENT TASK

Voice transmission quality of service (VTQOS) measurement is an emerging task that is widely required by network operators, state and regulation authorities, technology vendors and system integrators. There are many standards and methods for VTQOS measurement. The mostly used two methods are stated in ITU-T Recommendation P.861 (Perceptual Speech Quality Measurement – PSQM) and in ETSI Technical Report ETR-250 (E-model). In our example, the ETSI approach will be used.

E-model expects that the overall VTQOS can be evaluated as a non-linear combination of particular negative effects (impairments) that can be exactly defined and measured by comparisons between original and transmitted speech sample. The speech samples have to fulfill special requirements dealing with frequency content etc. and are usually built from several male and female voices of given language. The measured impairments are such as echo, overall loudness ratio, clipping, impulsive noise, psophometric noise etc. The resulting parameter is the R-factor that lies between 0 (worst quality) and 100 (best quality). Mean Opinion Score (M.O.S.) that reaches values between 1 (=worst) and 5(=best) is another representation of the result and is the recalculation of M.O.S. in almost linear way.

Each impairment is measured by comparison of selected part of speech sample using different algorithm (e.g. echo delay measurement is based on correlation algorithm or FFT can be used for psophometric noise measurement). To correctly interpret results, it is necessary to know and enter some specific parameters (room noise, expectation factor etc.) before start the measurement. For the same reason, it is recommended to acquire during measurement also additional parameters like overall transmission delay in speech channel. For mobile networks, also parameters of radio channel that is usually considered as the weakest part of the communication chain RxLev (electromagnetic field intensity) and RxQual (Bit Error Ratio for digitally modulated signals used e.g. in GSM or DECT) are acquired. This enables to find easily the reason of VTQOS decrease when it appears. From the above-mentioned short description should follow the complexity of VTQOS measurement task.

3 WRONG APPROACH I. – PURE SOFTWARE DEMONSTRATION

Other name for this type of lab exercise, given by students, is "slide show" or "couple of mouse clicks and leave". The basic principle of such approach is that the whole task is demonstrated using pre-programmed demonstration software tool. Although being usually animated beautifully, being filled by colored multi-dimensional graphs, comments, on-line interactive helps and explanations, there is no motivation for students to try to understand deeply all the steps, methods and algorithms. Experience shows that if even students think that they understood everything, it will be forgotten rather easily. This can be improved by adding some questions that have to be answered correctly to continue the demonstration.

Some better versions of software demonstrations allow enter and change values of input parameters. In this case, it is necessary to enable the user (student) to imagine the meaning of entered value. In our case, the simple dialogue box "Enter the value of echo loss [dB] and echo delay [ms]: " is worthless in this context – only few specialists can directly imagine if echo of -16dB@30 ms is in average more or less noticeable than echo of -11dB@3ms.

4 WRONG APPROACH II. – READY-TO-USE MEASUREMENT SYSTEM

Another way of non-effective laboratory exercise is the presentation of professional measuring system that has too many features and settings in the way which should enable the user to operate the system in the shortest possible time (students call this as "cookery-book exercise"). First half of the exercise has to be spent to acquaint students with system user interface ("The input settings have to be entered in the menu MENU-SETTINGS-INPUT SETTINGS. To do this, it is necessary to activate by left double-click the items MENU-SETTINGS-SYSTEM-BLOCK323 and de-activate the items MENU-SETTINGS-SYSTEM-HOOK_OFF_ENABLED_BY_USER and MENU-SETTINGS-SYSTEM-Q.651_STAT...") while the second half of the exercise is usually dedicated to setting the system ("Enter the following values FFT NUMBER OF POINTS: 512, WINDOW: HANN, OVERLAP 50, RECORD LENGTH: FULL, ZERO PADDING: NO. For value of AMBIENT NOISE, respectively EXPECTATION FACTOR, respectively BACKGROUND NOISE, enter the value –19, respectively 38, respectively –32. Check that all values that are in dB are entered in format xx,00 otherwise the system will crash after starting the measurement ! Use the speech sample etrssa.wav saved in c:\programfiles\qossystem\data\speech. You can also try etrssch.wav that is saved in the same directory..." Due to several mistakes made by students during settings, usually only few minutes at the end of laboratory exercise are dedicated for practical system usage and measurements.

If the system enables to load its configuration from file, it can significantly speed-up the setting but all parameters that are saved in the configuration has to be listed and commented in the manual or exercise book. In the opposite case, it will not be well understood by students what is currently being measured by the system and why.

5 WHERE IS BALANCE?

One feels that the right approach has to be positioned between both above-mentioned cases. In particular:

The measurement **task has to be exactly and completely specified at the beginning of the exercise**, to enable student to understand the relations and step order.

If professional measurement system is used, all **its features must be explained** in detail. The exercise handbook should contain not only which values have to be entered but also meaning and reasons for the particular values chosen. It is recommended **to load system settings from file** whenever possible. The configuration file should be carefully commented as described above. It is useful to separate the settings into different groups and layers. The less important system settings or settings that are not directly related to the discussed topic should be loaded from configuration file without highlighting them.

All settings that are given ad hoc **must be explained** and/or visualized. In our case, it must be possible to listen (using SoundBlaster and headspeakers) to signal that is affected by echo of entered parameters. Moreover, it must be possible to repeat it for several different values of echo delay and level.

A lot of vendors of professional systems provide **demo-version** of its software for free. These demo versions can be run on standard PC or even **from Internet** using Java-capable browser. Even

the restricted functionality usually does not allow to built a good laboratory exercise from it, it can be useful for its on-line help and to make students acquaint with the system user interface in advance.

The **attention** of students during exercise can be **raised by questions** or requirements ("How was this formula derived? Could you try to derive it yourself?") generated by the system or put by the assistant. These questions should not be blocking (it means students should be able to continue the exercise even if they answer in a wrong way) because otherwise some students can be stressed. Other way of raising attention are **interesting comments and practical applications** given by assistant ("By the way, this system can be used also for other voice transmitting devices than fixed and mobile phones only. It has been applied during the tendering on radio-communication system to be used by U.S. Army during...Which expectation factor would you set in the system for this purpose, by the way? Consider, please, that the military systems use much lower bit rates transmissions than the commercial one... " or "Do you know what is the main reason why network operators use such systems ? To achieve higher QoS to become more competitive? No – the differences in VTQOS of today competitive operators are usually not big enough to make anybody to change the operator. The main reason is that it was proven by statistic surveys that the better the VTQOS is, the longer the calls last in average...").

6 SOME MORE HINTS

From the above mentioned notes follow some obvious conclusions. Let us list them anyway:

The theoretical background of complex measurement must be given during **lectures in advance** in any case, no matter how the students "circulate" around the measurement tasks in the laboratory during semester.

Each student has to know in advance what will be the topic of his next laboratory exercise. It depends on the common rules of particular university whether the students will prepare themselves for the exercise in advance or not but it enables them to have this possibility at least.

When there is a possibility of having more and less experienced students working on the same task at the same exercise, it is suitable to have some spare tasks for the more skilled ones (scalable exercise) for obvious reasons.

References that are used in the handbook should have informative character only. There will be not enough time to search through several books, printout of standards and manuals during exercise, even if these are enclosed with the handbook.

ACKNOWLEDGEMENT

REFERENCES

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