Towards General-Purpose Annotation Tools – How far are we today?

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Abstract

This paper discusses the notions of special-purpose natural interactivity and multimodality (NIMM) coding tools, limited-purpose tools, and general-purpose tools as defined in terms of a set of key requirements. In the light of these requirements the paper presents a detailed comparison of three special-purpose and six limited-purpose coding tools and discusses the challenges in building a first general-purpose NIMM annotation tool.

1. Introduction

Current research in natural interactive and multimodal systems is generating an unprecedented need for annotation tools which can accelerate the process of building detailed knowledge of how humans communicate when exchanging information with each other or with systems, using speech, gesture, facial expression, gaze, body posture, and object manipulation as part of the communication. Given the important limitations of established theory on human communication, attaining this knowledge has become fundamental to the development and evaluation of increasingly advanced system generations.

Progress requires new high-quality data resources, of course, and new, well-founded coding schemes, but, arguably, annotation tools are the key to the efficient exploration of data and coding schemes since natural interactivity is immensely complex, including multiple levels and an abundance of within-level and cross-level coordination. While good special-purpose tools already exist for, e.g., orthographic or phonetic transcription of speech, a general-purpose coding tool has still to be developed. Even if no-general-purpose tool is likely to supersede the special-purpose tool in its limited domain of application, the wealth of aspects of human communication which remain unexplored makes it unlikely that we shall have special-purpose tools for them all in the foreseeable future. This is why the goal of creating general-purpose natural interactivity and multimodality (NIMM) annotation tools has attracted a good deal of attention during the last few years. A general-purpose tool is still far preferable to no annotation support at all.

Today's most general NIMM coding tools are only limited-purpose. The goal of developing a general-purpose NIMM coding tool thus remains an obvious next-step challenge. Two key questions are: what are the main functional, design and workflow requirements of a generalpurpose tool? And what are the main challenges facing its developers?

In the following, we first look back at how the need for powerful annotation support has evolved (Section 2). Section 3 presents a definition of special-purpose, limitedpurpose and general-purpose coding tools and the requirements a general-purpose tool would have to meet. Section 4 presents nine existing coding tools which are compared in Section 5. Section 6 discusses main challenges ahead in building a general-purpose tool.

2. The need for powerful annotation support

The need for annotation and annotation support tools is far from new. However, the complexity of natural interactive and multimodal communication poses new tools requirements compared to the earlier focus on unimodal, such as speech-only, data. For instance, annotation has been important in the fields of written and spoken language processing for more than a decade. Tools were mostly developed in-house for specific purposes and projects and were mainly used for coding speech and language data at single coding levels rather than across levels. A few tools came to be used by several sites, see [Isard et al. 1998] for a review. The EU MATE (Multilevel Annotation Tools Engineering) project (1998-2000, http://mate.nis.sdu.dk) went a step further by demonstrating a tool which could support annotation at arbitrary levels of spoken dialogue, including cross-level annotation, such as annotation of prosodic cues to semantics. Illustrating the difficulties of developing limited-purpose tools, the MATE result was a proof of concept but not a tool which was broadly usable in practice.

Significantly, the annotation support needs addressed in MATE remain largely unfulfilled. Moreover, current interests in natural interactivity and new modality combinations have created a strong need for coding tools far more powerful than the MATE Workbench. A coding tool community is emerging world-wide, aiming to speed up progress in NIMM coding tools and advance their underlying theory.

3. Special-purpose, limited-purpose and general-purpose tools

We distinguish between three different kinds of tools, i.e. special-purpose, limited-purpose and general-purpose tools. A *special-purpose* NIMM coding tool caters for coding NIMM communication at (a) particular predefined level(s). The best special-purpose tools have capabilities unlikely to be surpassed by limited- or general-purpose tools. A *limited-purpose* NIMM tool is meant for coding at multiple, non-pre-defined levels and across levels, but it still has some limitations which makes it unsuitable for certain kinds of coding; it includes some or most of the functionality of a general-purpose tool and can be defined in terms of what it lacks to become a general-purpose tool. A *general-purpose* NIMM coding tool supports – within the set of modalities it aims to

address - coding of arbitrary levels and modalities, across levels and across modalities. It offers the functionality and flexibility needed to span the implied broad range of possible coding tasks and to sufficiently support the different users who will carry out those tasks.

The idea of a general-purpose NIMM coding tool probably is only about 5 years old. The type of generalpurpose tool we consider here aims at supporting markup of modalities captured by audio and video. General requirements to such a tool would include the ability to:

- enable good and precise handling of raw data (audio, video), millisecond/single frame control, different data formats;
- support entry and revision of coding schemes;
- support efficient exploratory and mature coding, including time-stamped and structure coding;
- support efficient querying of coded data;
- support data analysis, be it via some basic statistics functionality, e.g. inter-coder agreement computation, or via export/linking to existing statistics packages;
- support import/export of coding files and query results in standard formats, e.g. XML;
- provide good and customisable visualisation of everything, including symbolic and analogue views;
- support meta-data descriptions. As opposed to the (fully) symbolic view, the "analogue" data view allows labelled segment time length visua-

lisation along a visible timeline. Structure coding enables cross-level linking of coordinated phenomena, temporally or otherwise, coded at different levels using different coding schemes. The listed requirements probably reflect broad consensus but the general requirements can be met in extremely different ways aiming at different user groups. The realisations of today's limited-purpose tools span from a do-it-yourself programmer's kit for satisfying – in principle - any particular coding and visualisation purpose to an easy-to-use non-programmers' tool for doing certain kinds of natural interactivity coding, sometimes visualising process and results in different customisable ways.

4. Existing tools for annotation of natural interactive and multimodal data

Special-purpose as well as limited-purpose tools are available for coding of NIMM data. Twelve of the most promising tools and tools projects in existence in year 2000 were reviewed in [Dybkjær et al. 2001]. Since then, some of those tools have been further developed and new tools have emerged. In the tables below, we compare nine existing coding tools. The three tools in the first table are special-purpose tools while the six other tools are limitedpurpose. The parameters included reflect the requirements listed in Section 3 and provide, in addition, some general information on each tool.

| Tool | Transcriber 1.4.2 | WaveSurfer 1.6.2 | PRAAT 4.1.27 |
|------------------------|---|--|--|
| Parameter | | | |
| Functionality | Segmentation, labelling, ortho- graphic transcription of speech sig- nals. Developed for broadcast news | Sound visualisation and manipula- tion, phonetic transcription, ortho- graphic transcription | Phonetic transcription, visualisation, analysis and manipulation of speech, orthographic transcription |
| Overall purpose | Special | Special | Special |
| Providers | Centre Technique d'Arcueil, France,http://www.etca.fr/CTA/gip /Projets/Transcriber/ | KTH, Sweden, http://www.speech.kth.se/wavesurfer | University of Amsterdam, The Netherlands, http://www.praat.org |
| Platforms | Unix, Linux, Windows | Unix, Linux, Windows, Macintosh, | Unix, Linux, Windows, Macintosh |
| Implementation | Tcl/Tk, C extensions, Snack sound extension | Tcl/Tk, Snack | C/C++ |
| Internal data rep. | XML | Text | Text |
| License issues | Open source, GNU General Public License | Open source, BSD style license | Open source, GNU General Public License |
| Supported formats | Most common audio files, e.g. wav, mp3 | Sound: wav, au, aiff, mp3, CSL, SD, Ogg/Vorbis, NIST/Sphere Transcription: HTK (and MLF), TIMIT, ESPS/Waves+, Phondat | aiff, aifc, wav, au, nist |
| Media control | Millisecond control via bar and buttons | Millisecond control via buttons and bar | Millisecond control via bar |
| Coding schemes support | Tags can be added/changed/deleted in the included scheme. Only orthographic transcription | Not really | None |
| Coding palette | Via keys | Almost none | None |
| Interface | No programming skills required | No programming skills required | No programming skills required |
| Types of coding | Time-stamped | Time-stamped | Time-stamped |
| Info extraction | Simple search | Via analysis tools | Search and via analysis tools |
| Analysis | None | Waveform, spectrogram, pitch, spectrum | E.g. spectrogram, pitch, formant, intensity, statistics (multidimen- sional scaling, principal component analysis, discriminant analysis) |
| Import/export | Export to: STM, Childes, LDC.typ, MATE; more can be added. Import from: .typ transcription files, | Used as widget in custom applications | Save to different sound formats |

| | xwaves, OGI segmentation files | | |
|------------------|-----------------------------------|--------------------------------------|-----------------------------------|
| Customisable | Fonts, colours | E.g. colours, sample rate, channels, | Sizing menus, fonts, views, sound |
| visualisation | | panes | devices, buttons |
| Coding file view | Analogue, symbolic | Analogue | Analogue |
| Meta-data | Limited, e.g. transcriber's name, | None | None |
| support | date, language | | |

| Tool | AGTK | Anvil 4.0.7 | Tasx |
|--------------------|---------------------------------------|--------------------------------------|---|
| Parameter | (Annotation Graph Toolkit) | | |
| Functionality | Software components for building | Annotation of video and audio data. | Annotation of video and audio data. |
| | annotation tools for audio and | Developed for gesture research | Time Aligned Signal data eXchange |
| | video data annotation | | format |
| Overall purpose | General in principle (do it yourself) | Limited | Limited |
| Providers | Linguistic Data Consortium | DFKI, Saarbrücken, Germany | University of Bielefeld, Germany |
| | http://agtk.sourceforge.net/ | http://www.dfki.de/~kipp/anvil | http://tasxforce.lili.uni-bielefeld.de/ |
| Platforms | MacOS X, Windows, POSIX | Unix, Linux, Windows, Macintosh | Windows, Unix, Linux, Macintosh |
| Implementation | C++, Java, Python, Tcl | Java | Java |
| Internal data rep. | Based on annotation graphs | XML | XML, relational database |
| License issues | Open source, OSI-approved | Free for research, not open source | GNU General Public License |
| | Common Public License | | |
| Supported | xlabel, TIMIT, Penn Treebank, | Formats supported by JMF 2.1.1, | Formats supported by JMF |
| formats | Switchboard, BAS Partitur, CSV, | including QuickTime and avi | |
| | LDC Callhome, aif | | |
| Media control | Examples show seconds for sound, | Milliseconds, frame, control via | Seconds (sound), frame, control via |
| | control via buttons and bar | buttons and bar | buttons and bar |
| Coding schemes | Supporting new coding schemes | Entering new coding schemes | No coding scheme can be indicated |
| support | requires programming skills | requires XML skills | |
| Coding palette | Yes, if the programmer made it | Yes, for the selected coding scheme | None |
| Interface | Only for programmers | XML skills needed to add new | No programming skills required |
| | | coding scheme | |
| Types of coding | Examples show time-stamped | Time-stamped, structure | Time-stamped |
| Info extraction | None | Search | Search |
| Analysis | None | Not much (Sonogram plug-in) | Via built-in link to PRAAT spec- |
| | | | trogram and pitch (in principle) |
| Import/export | Interfaces to WaveSurfer | Import from PRAAT, Xwaves, | Import from/export to, e.g., |
| | | export to ASCII format for SPSS | annotation graphs, Exmaralda, |
| | | | PRAAT; import from, e.g., Anvil, |
| | | | SyncWriter, Transcriber |
| Customisable | As much as the programmer | Colours, video size, speed of video, | Font size and type |
| visualisation | prepares for | collapse/open data groups | |
| Coding file view | Depends on programmer; can be | Analogue | Analogue, symbolic (only one layer |
| | both analogue and symbolic | | at a time) |
| Meta-data | Can be programmed | Little support (coder and coding | Via menu entries |
| support | | scheme) | |

| Tool | NXT | NWB 3 | The Observer |
|--------------------|---|--|--|
| Parameter | (NITE XML Toolkit) | (NITE Workbench for Windows) | |
| Functionality | Software components for building annotation tools for audio and video data annotation | Annotation of video and audio data | Annotation of video data. Developed for behavioural studies |
| Overall purpose | General in principle (do it yourself) | Limited | Limited |
| Providers | HCRC, Edinburgh, UK http://www.ltg.ed.ac.uk/NITE/ | NISLab, University of Southern Denmark http://nite.nis.sdu.dk | Noldus, Wageningen, The Netherlands http://www.noldus.com |
| Platforms | Unix, Linux, Windows | Windows | Windows |
| Implementation | Java | C++ | C++ |
| Internal data rep. | XML | Relational database | Relational database |
| License issues | Open source, GNU General Public License | Free for research | Commercial |
| Supported formats | E.g. avi, mpeg, au | wav*, au, aiff, midi, mp3, wma, asf, cda, avi*, mpeg, wmv, ivf, vob | E.g. mpeg, avi, QuickTime, Digital Video |
| Media control | Examples show video frame control via buttons | Millisecond, frame, control via buttons | Frame, control via buttons, seconds shown |
| Coding schemes | Entering new coding schemes | Interface for entering new coding | Interface for entering new coding |

| support | requires XML and stylesheet skills | schemes | schemes (configuration) |
|------------------|------------------------------------|-------------------------------------|---------------------------------------|
| Coding palette | Yes, if the programmer made it | Yes, for the selected coding scheme | Yes, for the selected coding scheme |
| Interface | Only for programmers | No programming skills required | No programming skills required |
| Types of coding | Time-stamped, structure | Time-stamped | Time-stamped |
| Info extraction | Query via own query language | Query via SQL interface, search | Search |
| Analysis | None | None | Time events, reliability, elementary |
| | | | statistics, lag sequential analysis |
| Import/export | Can be programmed | Export to XML | Export to formats for further |
| | | | statistical processing, import of |
| | | | graph (bitmap) and Ethovision data |
| Customisable | As much as the programmer | Colours, zoom, timing (seconds, | E.g. speed, timing, toolbar, auditory |
| visualisation | prepares for | frames) | feedback |
| Coding file view | Depends on programmer | Symbolic | Symbolic |
| Meta-data | Can be programmed | Free form text meta-data can be | Some (fixed) parameters can be |
| support | | entered in meta-data table | entered via configuration |

5. Comparison of tools

The three special-purpose tools are all specialised to address particular well-defined codings of audio files such as orthographic transcription. They offer good control of the sound signal. The two tools supporting phonetic transcription (WaveSurfer and PRAAT) also offer a number of speech signal analysis tools. But since the tools are not meant for other types of coding than they were designed for, there is close to no support for coding scheme changes, the type of coding is time-stamped only, and the offered customisations are limited to those known from many other programs, such as colours and fonts.

The six limited-purpose tools all have in common that they are not meant to handle pre-defined coding levels. On the other hand, none of them provide sufficient support for arbitrary coding of audio/video data to be called generalpurpose tools. Two of them (AGTK and NXT) are do-ityourself tools. They come with examples but otherwise leave it to the user to build the tool needed based on the offered components. Do-it-yourself tools may be useful if nothing better is around, if a programmer is available, and if one needs functionality which comes fairly close to the included examples. If the latter is not the case, it may be faster and better to tailor a tool to one's needs just using an ordinary programming language. AGTK examples show audio control but no video control. NXT examples show video control but no audio control.

The limited-purpose tools often reveal, via their strong and weak sides, what they originally were developed for. For example, the Observer has quite limited support for handling audio data and spoken dialogue, and Anvil reveals in its visualisation that focus has not been on spoken dialogue annotation. The analogue coding file view is often sub-optimal for spoken dialogue coding.

One issue which really categorises all these tools as limited-purpose rather than general-purpose is the lack of an appropriate interface for entering new coding schemes and the possibility to enter any coding scheme which one may find relevant for the kind at raw data that can be handled by the tool. NWB and the Observer have interfaces for coding scheme entry. However, none of them are easy to comprehend and, in both cases, there are limits to which kinds of coding schemes can be entered.

A second issue is the customisation and visualisation options. A general-purpose tool would need very considerable flexibility in these respects since it would have to accommodate many different needs and preferences. As an example, most of the limited-purpose tools only offer either a symbolic or an analogue coding file view but not both nor at the same time. Also, most tools only offer time-stamped coding. This makes a tool unsuitable for the coding of cross-level and cross-modality relationships. Moreover, the kinds of customisation offered are typically quite basic, such as fonts, colours, size, zoom and speed.

Sophisticated information extraction is frequently missing apart from some kind of – often not very advanced search. Exceptions are NXT which includes a query module with a home-grown query language and NWB which offers information extraction via an SQL interface. None of these interfaces are for novice users, however. Analysis tools are typically absent apart from what has been made obtainable via plug-ins and links (Anvil, Tasx). Only the Observer includes some simple analysis tools and – importantly – supports export to existing statistics packages.

Meta-data support has received varying attention in the reviewed tools from close to no support to some support.

6. Challenges ahead

Comparing NIMM coding tools is clearly a multidimensional exercise. No tool is just simply better or poorer than another. But we have still not many tools to choose among, and a general-purpose tool is still a challenge for the future.

As we see them, the three main challenges in building such a tool are: how to allow for easy entry of coding schemes of one's own choice or design, how to enable unlimited cross-level and cross-modality coding, and how to provide sufficient flexibility in visualisation to optimise presentation of data coded by using arbitrary (sets of) coding schemes.

References

- Dybkjær, L., Berman, S., Kipp, M., Olsen, M. W., Pirrelli, V., Reithinger, N. and Soria, C.: Survey of Existing Tools, Standards and User Needs for Annotation of Natural Interaction and Multimodal Data. ISLE Deliverable D11.1, 2001.
- Isard, A., McKelvie, D., Cappelli, B., Dybkjær, L., Evert, S., Fitschen, A., Heid, U., Kipp, M., Klein, M., Mengel, A., Møller, M.B. and Reithinger, N.: Specification of workbench architecture. MATE Deliverable D3.1, August 1998.