Longevity of Music Media

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I was reminded of the seriousness of this issue by two things; one is an article in the MIT Technology Journal that discusses the problem of long term storage of digital media, and the other was an article in one of the pop news magazines about the long term storage of data from digital cameras.

The MIT article discussed the problem of data coding and decoding in a technology where standards are largely driven by market forces. For instance, users of Encore 4.1 found, much to their distress, that an upgrade to Windows XP rendered the program inoperable, and thus their data and music unreadable. A required upgrade to Encore 4.2 (and its new data format) then rendered the data unreadable to anyone running Encore 4.1.

A similar situation happens to any user of Microsoft Office. Software upgrades render documents unreadable to previous versions. The only solution is to upgrade. These are format changes that occur at least every three years. What MIT was worried about was whether or not the historian 100 or 200 years from now would be able to decode important and historic documents, pictures, music etc. when it was created under such circumstances.

Aside from format problems, there is the question of the storage media. (The oft-repeated horror story is that there is data from the Voyager probe that cannot be read. Either the oxide falls off the tape, or the data has 'faded,' or there are no machines available that can read the tape; they were all sold off during hardware upgrades or can't be fixed for lack of parts.) One of the media mentioned as being the best hope for long term storage was paper (albeit a very specialized archival kind of paper).

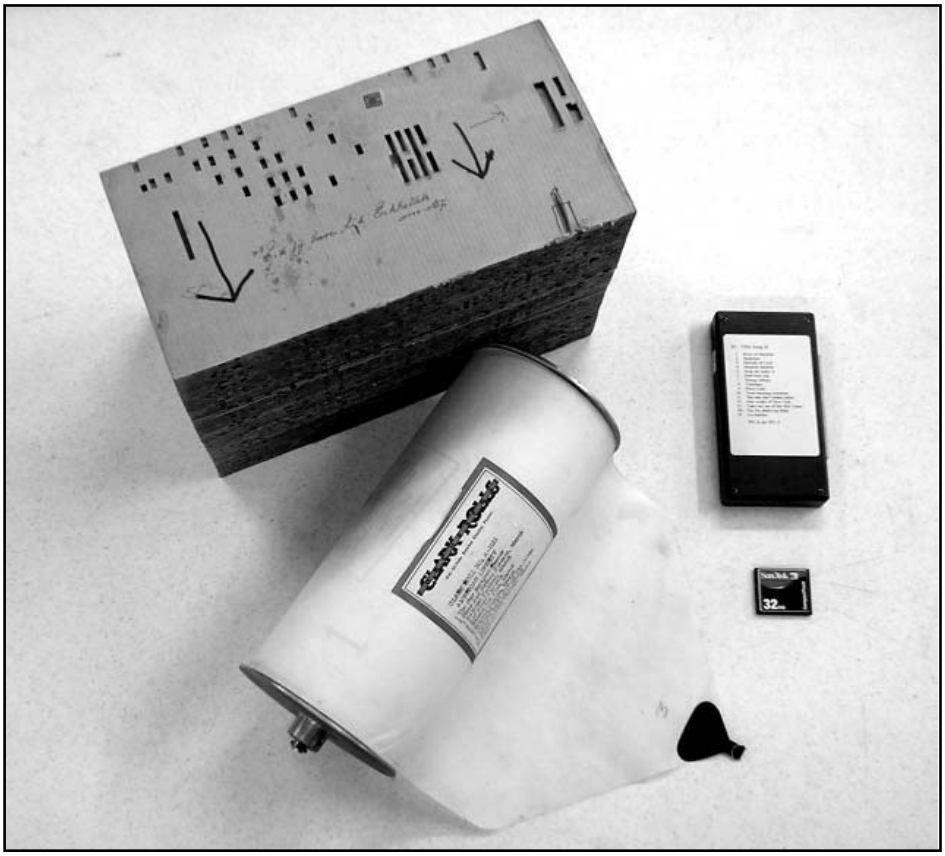

Figure 1. Conflicting storage media for mechanical organs and air calliopes—perforated books (DeCap) and rolls (calliope) versus computer chips (Hofbauer) and storage cards.

The pop magazine article was on a similar issue. Users of digital cameras are discovering (too late) that their images are very fragile. A simple hard disk or floppy crash destroys them. More interestingly they are finding that common transfers of those images using ink jet printers as equally as fragile. Ordinary jet paper and ink don't hold color quality. Mixtures of paper types and ink types have the same result.

The only thing that appears (for the short term) to have any hope of lasting is paper and ink obtained directly from the printer manufacturer; because that paper and ink is specially engineered for that printer. For the long term, the only thing that appears to have any hope of surviving decades or longer is to have the digital images transferred to ... high quality photo paper using traditional methods!

The reason to store the data for mechanical musical instruments on paper is that it has been empirically proven to last longer. The reason to store the data as holes punched in the paper is because the data will not fade or distort or otherwise lose meaning and thus be un-retrievable. We do not have to worry whether or not the data can be read 100 or 200 years from now. Even if badly or naively stored, the data will still be readable. This media has an excellent long-term track record. Modern digital media has an awful track record. In only 30 years, valuable unique historical data from Voyager is irretrievably lost.

Imagine the horror that awaits the roll manufacturer who has their masters stored on 5 1/2 inch floppies playable only on 20 year-old hardware. Run forward another 20 years to the archivist faced with cracked CD-W media that can only be read on 20 year old CD readers mounted on 20-year old hardware, or 20-year old backup tapes that can't be read at all because the hardware can't be found to read them. The list goes on and on.

When the current members of the roll scanners group go to their great reward, who will take over the maintenance of the storage media on which their work has been preserved? It's a roll of the dice to know if the media will fall into the hands of interested and caring archivists, or dolts who just pour all the stuff in cardboard boxes and shelve it.

Digital media requires much more intensive care and ongoing attention if the information is to survive.

We know what happened to punched paper media when the archivists just piled the stuff in cardboard boxes and shelved it. It is still readable 100+ years later, having been given no better care than to make sure it didn't catch fire or the rats and bugs didn't eat it.

Aside from longevity, there is the issue of accuracy. If you are with me so far, and agree that paper is the media that has the best chance of being around 100+ years from now, then you'll now see the reason for extremely accurate scanning and perforation.

I now turn to a technology that is producing the closest thing available today to perfect re-creations of the original data—the combination of Wayne Stahnke's data sourcing technology, and Dave Saul's perforating technology. I say closest thing because there is still the question of punch diameter and paper advance mechanics (is it capstan advanced or take-up-spool advanced?).

If one doesn't consider these for the moment, then this combined methodology clearly produces perfect copies of the original data. I say this because in the transfer from original to copy, there is no impedance mismatch. One data point in a row in a matrix represents one punch in a discrete position on the paper. The next row in the matrix represents one advance of the paper. More to the point, the software that scans, manipulates and encodes the data and the equipment to punch the roll are designed precisely to do only the above. One data point represents one punched hole.

MIDI does not describe a discrete position in two dimensional space. It describes an event in time. To achieve a punch point description in strict MIDI requires a MIDI On at a point in time, and a MIDI OFF at another point in time. One can jigger this to achieve a mock singularity (the on time is the same as the off time, or one just chooses to use only ON times), but the act of jiggering the standard at all implies that the standard is being used in a non-standard way—hence impedance mismatch.

A similar mistake is to assume that a finer granularity in the data representation will achieve the same level of perfection in the finished product. It cannot do this for the same reason that one cannot blindly convert between floating point representation of numbers and integer representation of numbers and be dead certain of the outcome. 1 divided by 3 stored in integer arithmetic does not yield 1/3 when subsequently retrieved (it comes back as 1). 1 divided by 3 stored in floating point comes back as a close approximation of 1/3.

A value stored in integer arithmetic can be compared with another integer and the result (is there a match or not) is a completely reliable answer. A value stored as floating point, compared in the same manner is NOT reliable. A lot of work must go on inside computer programs to correctly determine the outcome of a test for value match between floating point numbers. So you can see that naively converting between integer and floating point during calculations can produce significant data skew. For this reason, most financial packages do all the calculations in integer arithmetic and specify where the decimal point should appear in the printout.

Similarly, scanning and perforating methodologies that convert between different data representations are by definition inaccurate. They cannot be accurate because there are constant compromises and recalculations that occur when determining the discrete punch position that the data represents. In the jargon, these are called "sampling errors." At its worst, this produces rolls like the early days of recutting where onset and offset of ports can vary by as much as a 1/16-1/8 of an inch. Chords come out as arpeggios. Dancers lose their balance. Every subsequent generation using such methods only gets worse.

The Stahnke/Saul combination introduces no impedance mismatch and no sampling errors and hence is reliably accurate; subsequent generations using the same methods will not introduce further errors. One single data point represents one punch in a discrete positional matrix. There is no intermediate interpretation or recalculation performed during the transfer between data point and punch operation.

One does not have to interpret something like "the original slot is AA inches long at tempo BB, which sort of equates to CC midi ticks which sort of equates to DD micro punches." Instead, the transfer between a data point and a punch operation is "The machine should now punch a single hole at row AA, port BB." Thus there is no necessity to adjust for things like the effect of errors introduced by tracker bar port size during pneumatic scanning. A two-punch slot is two punches in length, not NN ticks long being translated to YY micropunches long.

> As a side benefit for the archivist 100 or 200 years hence, since the scalloping produced by the perforator will be preserved during the recreation, the original master matrix will also be available in the same way that it is available to us today. Thus even if the digital version is lost, the accurate matrix data will still remain.

To conclude, I strongly urge those who are scanning rolls to consider using perforated media as the long-term storage of choice. High quality (even low quality) paper is proven to last 100+ years even under hostile storage conditions. I further urge those who are perforating rolls to consider very carefully the methods used to read the original data and perforate the final output. 100 or 200+ years from now, long after the primary sources have crumbled into dust, a copy that "sounds good enough" or is a "reasonable facsimile" will not cut it. Years from now do you want to be remembered for "Clark" quality or "Capitol" quality?

Unless you adopt methods that produce accurate punch for punch copies from expertly restored master images, like the ones described above, you will be producing distortions (high-quality representations but distortions none the less) and thus doing a disservice to yourself and posterity.

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