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ABSTRACT

This paper discusses the benefits that may be realized through "running" time compression (RTC) of video material. RTC is the playback of audio/video at a temporal frame rate faster (with audio pitch correction) than that used when recorded. Previous research has shown that RTC can enhance learning and the retention of content; RTC in both audiotape instruction and in television commercials has had a positive effect on viewers' attitudes towards on-screen presenters, recall of information, and attentiveness; or that there was less evidence of positive effects but no indication of negative effects within average RTC levels. The paper includes a discussion of aesthetic consequences of time compression; time compression for instructional and educational applications; methods of applying running time compression; and problems with time compression. It is concluded that, considering the potential benefits of more content delivery in less time, the weight of evidence that supports learning improvement, and even media storage economy, time compression should be seriously considered in video and multi-media-bound production. Two appendices provide a reproduction of the On-Screen Time Compression/Expander menu used in the Digidesign "Sound Designer II" Macintosh-based software and primary subject motion revealing and concealing motion artifacts from a demo video. (Contains 15 references.) (MAS)

Speed: "Run" - Time Compressed Video for Learning Improvement and Digital Time Compression Economy

by Gregory Gutenko

Abstract Gregory Gutenko

This paper discusses the benefits that may be realized through "running" time compression (RTC) of video material. RTC is the playback of audio/video at a temporal frame rate faster (with audio pitch correction) than that used when recorded. Studies in cinema, advertising, education, and psychology suggest that RTC can enhance learning and the retention of content. Also, any reduction of original video time through RTC will save storage media real estate in the digital realm.

Research has shown that (RTC) time compressing in both audiotape instruction and in television commercials has had a positive effect on viewers' attitudes towards on-screen presenters, recall of information, and attentiveness (LaBarbera; MacLachlan; Levere; Moore). Other studies have found less evidence of positive effects but no indications of negative effects within average RTC levels (Vann; Riter). The outcomes of these studies will be summarized.

Historical support for RTC as a valid general process, and not as just an occasional special effect, is Brownlow's study of early silent film shooting and projection practices; it was typical for most films to be projected at a faster frames per second rate than as filmed, and this was a consequence of deliberate aesthetic preferences. Contemporary studies have found that temporal cues are correlated with spatial and scale cues (Scanlan; Mitchel) and that small images tolerate or even better fit a reduced temporal scale (RTC). Together, these studies suggest that video may not necessarily require or even benefit from recording/playback speed consistency.

Both digital tape and non-linear disk editing methods and technologies offer easy RTC application. Considering the potential benefits of more content in less time, improved learning, and media storage economy, run-time compression should be considered in video and multi-media production.

Speed: "Run"-time Compressed Video for learning improvement and digital time compression economy.

Gregory Gutenko

Time compression is the process of playing back audio, video, or film material at a speed, or frame rate, faster than that at which it was originally recorded. (This is distinct from digitally-based processes used to compress data files.) Television audiences encounter time compressed programming and advertising on a daily basis, and have been doing so since the early 1980s. This fact ought to be a revelation to most viewers since time compression is intended to be perceptually undetectable, an "invisible" means of packing more programming into less time.

Time compression (or expansion) essentially means fast (or slow) motion, but at a rate which does not produce an exaggerated visual effect. Obvious visual speed changes are revealed by abnormalities in inertial motion, a too rapid or too slow an acceleration or deacceleration of a moving mass. Inertial motion -- sometimes referred to as *damping* in digital video effects motion programming -- is a visual speed cue. Obvious speed changes would be on the order of 50% or 200%. Plus or minus 5% to 10% would not be obvious, and even a 20% variance can go subjectively unnoticed. We also subjectively perceive audio, video, and film speed changes by changes in sound *rate* and *pitch*. What is most quickly and easily noticed, and at only moderate deviations in speed, are changes in *pitch*.

It is a common technique in popuiar music (eg. Kate Bush) to use audio processing devices to maintain normal rate but apply altered pitch so as to create unusual vocal treatments. A sampling keyboard is an example of a device with pitch adjusting capability. In correcting video or film sound undergoing time compression, what is needed is an altered rate with normal (corrected) pitch. Various tape machines (analog and digital) can speed up video and audio by incremental amounts while providing a converted video signal output of 30 frames per second. *Audio pitch correction* is the key to keeping modest speed changes "sounding" and "appearing" normal. Sound pitch correction is done by an external audio processing device, such as the *Lexicon* (which has a foothold in the broadcasting industry). Many other devices are from the music world (*Eventides* Harmonizer). The technology of time compression, then, is primarily that of sound quality restoration using a pitch adjusting device.

Researched Effects of Time Compression

For broadcasters, the primary value of time compression is to squeeze more programming capacity out of the finite 24 hour day. Running a complete and intact 28 minute syndicated program in only 26 minutes recovers two minutes of airtime that can be sold for additional advertising revenue. This also eliminates the work time required to edit down a program to open up this additional airtime, along with the staff needed to do the editing. For non-broadcast applications in education and training, reducing presentation time may not yield such obvious and direct cost savings, but would economize on the time needed in cla... and study media use.

Besides time-based economic benefits, improved viewer attention, attitudes, and information recall have been attributed to time compression. The original *Lexicon* audio processing device was developed to reduce listening time when studying from audiotapes, and so the effects and consequences of using time compressed material was under trial and study by educators and academic researchers from the very inception of the technology. In 1980, LaBarbera found that students preferred using audio and film materials that were compressed by 25%, and that they found the presentations to be more interesting, articulate, and generally more memorable. Studies on compressed radio and television commercials found that compression resulted in greater appeal

(MacLachlan and LaBarbera, 1978) and greater message recall (MacLachlan and Siegel, 1980). However, Stephens found that the level of message recall was age correlated, with compression having a positive effect for young adults (college students), no significant effect for middle aged adults, and a negative effect for adults over sixty years of age (1982).

In addition to levels of interest and general recall, later studies articulated the effects of compression to include persuasiveness and source credibility, attitude change, information processing, and argument or process comprehension. MacLachlan found that radio listeners perceived compressed radio commercial spokespersons to be more confident (1982) and Moore, Hausknecht, and Thamodaran also found increased source credibility (1986) to be a result. However, in the latter study it was found that compression also led to fewer cognitive responses, suggesting that increased persuasive appeal was the only clear benefit of compression and that "cognitive elaboration is disrupted". Similarly, King and Behnke found that while interpretive and short-term memory performance increased with high levels of compression (up to 60% speed change), comprehension performance decreased (1989).

There have been other studies, however, where minimal or no significant effects were found for or against compressed radio and television commercials (Riter, Balducci, and McCollum, 1983; Schlinger, Alwitt, McCarthy, and Green, 1983). This suggests that moderate time compression (20% or less) does not significantly hinder or interfere with communication and therefore can be considered at least a benign and harmless process. Aside from the inconsistency between positive and null findings, another concern regarding this body of research arises out of the strong interest by advertisers and broadcasters in compression applications, which has directed the focus of research almost exclusively towards radio and television commercial content. The original raison d'être for time compression -- improved learning from media -- has not been adequately tested. However, in addition to the problematic but somewhat encouraging empirical evidence cited here, there are a number of aesthetic arguments which recommend time compression as a creative tool.

Aesthetic consequences of time compression

Speed is not sacrosanct. It might appear that the "right" speed for playback is the speed used during acquisition, and certainly this assumption is constrained by the lack of convenient playback speed adjustment on most video and audio recorders. We do not hesitate to change *perspective* every time we deviate from the "normal" 45° angle of view focal length lens or zoom setting when shooting video or film. The shape of the visual field is drastically changed and reduced when we crop from the essentially circular 160° field of view of the human eye coverage (Callenbach, 1961) down to the rectangular image frame inherited over great cultural distance and time from paintings, windows, and portals. The limits of film and video technology result in extreme changes -- losses -- in color values and resolution. So why should speed be left unchanged, especially if such manipulation might compensate for the losses incurred by photographic technology? Certainly, there is no aesthetic support for maintaining such conformity, and much to suggest otherwise.

Kevin Brownlow, through diligent practical research to discover the true projection speeds required for silent films to be used in the television series *Hollywood* (Thames Television), found that there was no absolute consistency between silent-era camera and projector speeds, and that in fact it was typical for projection speeds to be 10 to 20 percent faster than as filmed. This variance was possible because silent-era cameras and projectors were either hand-cranked or were driven by variable-speed rheostat controlled motors. While 16 fps (frames per second) is usually cited today as "the" silent speed, standards of the period were not absolutely set, varied depending on the director or camera operator, and even were more often expressed in terms of 1,000 foot reels per *X* minutes (most commonly 16 minutes) rather than in frames per second.

Brownlow's evidence for actual proscribed projection speeds was found in the musical scores that accompanied these films while in circulation. The score composer would often determine the most appropriate projection speed for a film on a scene by scene basis, and commit these instructions to the score. Secondary evidence was found in the published showtimes of individual theaters; the start and stop times indicated how fast a film had to have been projected in order to fit the day's schedule. Brownlow's evidence of creative, evocative film playback speed variations, found in music score notations, showed that speed change during projection (both faster and slower than in the camera) was an often-used creative tool (1990). As Brownlow quotes D. W. Griffith, "The projectionist in a large measure is compelled to redirect the photoplay".

Speed change was a significant and effective creative technique until sound film synchronizing requirements compelled adoption of a fixed and consistent speed (24 fps). From this point on, speed was no longer a free production variable, shakeled as it were to the ponderous constraint of a sound track. Should speed stand inviolate today? Obviously, broadcasters would not agree, but for them time compression is primarily a means to gain airtime and revenue, not to evoke aesthetic responses. (However, "tabloid news" programs such as *Inside Edition* have exploited extreme levels of compression to intensify the emotional and physiological effects of their "reportage".) Filmmakers are also convinced that time compression alters the audience effects of their products when telecast, only in these cases such alterations are considered a form of artistically destructive tampering akin to colorization and re-editing (Sukow, 1992; McBride, 1989). Here, time compression alters audience perception in a manner outside the control of the artist. Advertisers certainly use compression to enliven commercial performances and to enhance visual dynamics, in addition to such pragmatic ends as reducing spot lengths that come out over-long during production, or to make room at the end of existing spots for short tags that update or change copy points.

Another aesthetic point in favor of time compression control is suggested by a human perception study by Mitchell and Davis. They found that small scale environments (such as in model railway layouts) are related to the "compression" of subjective time relative to clock time (1987). It was hypothesized that the effect of "time compression" may be correlated to differences in the density of visual information to be processed in the environment. Where video and film is concerned, this means that less time is required to perceive the essential aspects of an event when it is on a small screen rather than on a larger screen or in real life. Filmmakers working in both large screen film formats such as IMAX and Panavision and in video have noted that individual shots must be timed differently due to image size and detail, with less running time allocated to shots used in television projects. It may follow then, that a presentation which subjectively seems well paced live in the classroom will appear too slow when viewed on video or film. Time compression in this situation would help ameliorate the subjective perception of a slow video presentation.

Time Compression for Instructional and Educational Applications

While special motion effects are often used in entertainment film and television to suggest extreme emotional states or moments of intense experience (with real-time sound as in Peckinpah's *The Wild Bunch* or slow-speed sound as in *The Long Riders*) or for an exaggerated comical effect (*The Gods Must Be Crazy*), instructional and educational media producers have generally used special motion effects sparingly, and more often to analyze and illustrate processes or human movement than to influence viewers' subjective behavior. The dynamic tracking capabilities of most videotape formats and the technique of editing with EDL-managed "fit-to-fill" variable speed control has widened the availability of the time compression option.

Time expansion can still be used to more carefully display critical actions, but reinforcement and review of such segments (which otherwise might be in real time or in still images) can now be done using time compression. For material destined for digitized formats such as CD-ROM, a reduction in video material would also lead to a (modest) saving in digital real estate demand (but not as much as would be obtained using digital compression level changes). However, time compressed video would be fully lossless.

Methods of applying running time compression

The most uncomplicated method of applying time compression is to take the process "out of house" to a local television station or video post-production company with a *Lexicon* or similar device. This would mean committing to the rate of compression for an entire finished project, or to selected footage to be edited later. If videotape machines are available "in house" which are capable of variable fixed playback speed with dynamic tracking, then the audio signal from the source machine(s) can easily be routed through an in house owned audio compressor/expander with pitch correction. Correcting audio pitch is necessary, however, only if fully synchronized audio is needed.

Sync sound is often unnecessary, and time compressed video can easily be matched with uncorrected normal speed audio edited in separately. It is, in fact, frequently an aesthetically superior editing technique not to use fully synced video and audio tracks (as in assemble mode editing). It may be necessary for there to be only an *appearance* of synchronous sound, and to combine video and audio tracks independently using insert mode editing. It is often preferable to have a scene constructed with an single, continuous, unbroken audio track/edit in combination with multiple video shots/edits. Otherwise, as in assemble editing, there may be audible changes at each video edit point.

Additionally, a shot with only one sync "event" or moment within it can also be edited together using separate video and audio edits; the audio and video tracks can be slipped together until the single action and sound event are aligned. It may take some initial courage to consider separating video and audio that have been conveniently recorded in sync, processing each differently, then bringing them back into sync again by eye and ear, but this is not as difficult as it might seem. Most of the sound sources heard in film and television entertainment programs were not recorded in sync (were recorded "wild"), but were aligned in the editing process to create the illusion of on-camera sound. For those fortunate to have time-code based production and editing resources available to them, disconnecting video from audio for independent processing should be the standard and preferred practise.

Video production on computer has a different set of challenges associated with time compression. Non-linear editing software (eg. *Avid*, Adobe *Premier*) allows for video time compression at the click or slide of an on-screen button. However, these editing programs provide little in the way of significant audio processing, and as of this writing, time compression with pitch correction is not an available option. Again, if full sync sound isn't required, this is not a problem. If it is required, as with continuous on-camera speech, software designed expressly for audio work (such as Digidesign *Sound Designer*) must be used. At this time, the capabilities of full video and audio processing within one software product is not yet available, and separating video from audio is necessary to perform time compression on computer. Those video and audio programs that provide time code tracking of material allow the only sync trouble-free exchange of audio in and out of different programs.

Problems with time compression

One reason why is isn't so easy to provide audio pitch correction with time compressed computer-based video editing has to do with the different deletion frequencies by which video and audio are typically compressed or expanded. In the compression of audio, a *Lexicon*-type device deletes very small segments -- on the order of one fiftieth of a second -- and many of them from the incoming audio signal, and the gaps so created are filled when the remaining signal is "pushed together" to reduce time duration. For audio compression to sound even and natural, this small unit-high frequency level of deletion is necessary.

In the case of video, there are only thirty frames per second of video information available to work with, and this then is the finest resolution or smallest unit of deletion possible. This essential deletion rate discrepancy in compression means that video and audio cannot be processed simultaneously by the same mathematical schema -- a pair of interconnected yet independent programs must be operating simultaneously. This capability is not an impossibility, it is just far from easy to engineer, and is not likely to appear together until there is sufficient consumer demand.

The comparatively coarse scale of information deletion in video results in an often noticeable and distracting discontinuity of motion. At a 10% level of compression, a one second duration clip of video will actually be running at 33 frames per second, and the compression process will drop one frame at ten frame intervals. These lost frames result in motion skip, and higher levels of time compression will yield more instances of "skip frames". Older tape machines such as the Ampex VPR-80 (one inch type C format) may be irregular in their skip frame intervals, and only certain fixed speed settings will result in a minimization of motion artifacts; time compression from analog tape formats is not highly variable. Digital tape machines such as D-1 and D-2 are able to distribute dropped frames more evenly and consistently, but here also specific recommended speed settings must be used.

Motion artifacts are least noticeable with time compression on non-linear computer based editing systems. Digital frame interpolation can synthesize "blended" frames that visually bridge the gap across skipped frames, and speed control can be considered infinitely variable. Unfortunately, external audio compressor/expanders cannot be added "in line" to a computer based editing system. Video and audio information files exist in the computer domain only as original digitized input; there is no creation of a new generation of modified and rearranged video or audio material as in tape editing. Motion effects and all other apparent editing manipulations are strictly sets of instructions on how to play back the original digitized files and these files cannot be "looped" outside the computer and returned in an altered form.

Conclusion: To use or not to use

Despite these particular technical obstacles, time compression not a difficult to apply technique, especially when insert editing and "wild" (non-synchronous) sound are used. Time compression should not , however, be considered an arbitrarily plugged-in effect. As Vann, Rogers, and Penrod noted, many aspects of time compression remain unresolved. While it appears that audience factors such as information recall, beliefs, and behavior remain unaffected while interest, attention, and approval can be improved, it is also evident from both their own research and that of others that time compression has an unpredictable influence on interpretive cognition, critical responses, and argumentation. Differences in these latter factors is difficult to evaluate as being more or less desirable (1987).

Will students find time compressed material more stimulating and so attend more closely to the information and ideas contained therein, provoking a higher level of recall, cognitive engagement and analysis? Or does time compressed material flash by too quickly, so that certain points are missed and resulting cognitive responses differ because they are based on incomplete apprehension and comprehension of the material? Obviously, more research is merited.

However, considering the potential benefits of more content delivery in less time, the weight of evidence that supports learning improvement, and even media storage economy, time compression should be seriously considered in video and multi-media-bound production. Van, Rogers, and Penrod have suggested that the effects of time compression ultimately depend on and interact with the unique effective characteristics of the material itself. Just as some films, commercials, and programs will be negatively altered if not unfolded at their naturally slow pace, some instructional deliveries will also be interfered with if they are artificially accelerated. Ultimately, as is the case with choices regarding lensing, lighting, graphic support, dramatization, etc., the application of time compression is a judgment call. It is a tool to be used with understanding and an appreciation of its power to alter how things are seen and heard and understood.

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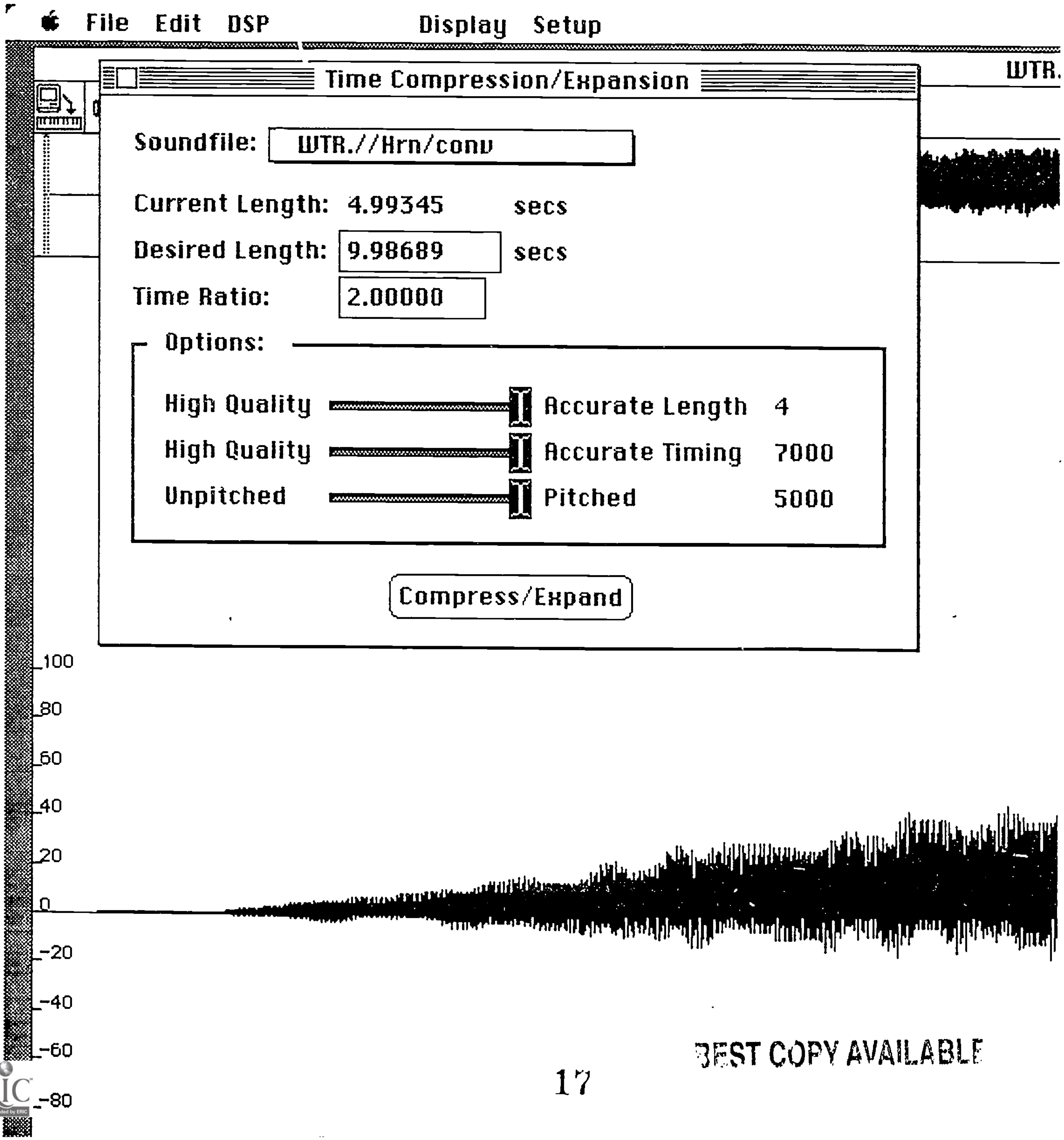
Appendix A

On-screen Time Compression/Expander menu used in the Digidesign™ *Sound Designer II* Macintosh-based software



Appendix B

Primary subject motion revealing or concealing motion artifacts (from demo video)

Frame A: Continuous cross-screen motion (x- and y-axis motion) by subjects or through camera panning or tilting suffers the most from noticable skip-frame losses and motion discontinuity.

Frame B: Irregular movements either in place or to and from camera (along z-axis) are the least exhibitive of motion artifacts and can sustain higher levels of time compression before appearing unnatural.