GeoTracks: Adaptive Music for Everyday Journeys

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ABSTRACT

Listening to music on the move is an everyday activity for many people. This paper proposes *geotracks* and *geolists*, music tracks and playlists of existing music that are aligned and adapted to specific journeys. We describe how everyday walking journeys such as commutes to work and existing popular music tracks can each be analysed, decomposed and then brought together, using musical adaptations including skipping and repeating parts of tracks, dynamically remixing tracks and cross-fades. Using a naturalistic experiment we compared walking while listening to geotracks (dynamically adapted using GPS location information) to walking while listening to a fixed playlist. Overall, participants enjoyed the walk more when listening to the adaptive geotracks. However adapting the lengths of tracks appeared to detract from the experience of the music in some situations and for some participants, revealing trade-offs in achieving fine-grained alignment of music and walking journeys.

Keywords

Music; soundtrack; mobile; pedestrian; walk; commute; adaptive; experience; geotrack; geolist.

1. INTRODUCTION

Many of our everyday music listening experiences are concerned with accompanying our commonplace travelling and housework chores [19]. Mobile music listening, particularly in mundane settings such as a commute to work, can "*serve to alter perception of surroundings, not simply by enhancing awareness of particular features*" [13]. For example an individual's curated playlist can 'aestheticize' the urban environment, turning a journey into a personal narrative [5]. Over the last 15 years locative media experiences have sought to re-connect us to environments through bespoke soundtracks that adapt to our trajectory through a space [2]. But these are not everyday experiences and typically they do not engage with music of our own choice.

Our aim is to make people's own music and playlists more responsive and in-touch with their everyday journeys, so as to form a stronger connection between music and place that enhances the experience of both. Thus, we are not concerned with the creation of original music, but rather the adaptation of existing commercial music, situated within everyday listening such as urban pedestrian commuter journeys.

In this paper we present the "geotrack" concept, and a prototype geotrack music player application in which the structure of a song is rearranged, or re-worked, to match both the context and user activity, in this instance driven by GPS location sensing (section 3). We have developed a process and a set of methods for track adaptation, as undertaken by our composer (section 4). Finally, we have evaluated the created geotracks through a naturalistic study, comparing two similar journeys, one with a regular playlist of music and one with adaptive geotracks (section 5).

2. RELATED WORK

We begin by reviewing related works in locative media and clarify their relationships to the geotracks proposal. We then consider other precedents for re-arranging music, which is an essential component of geotracks, and emerging formats for interactive audio that might support geotracks in the future.

2.1 Mobile, Context-Aware and Locative Music Listening

There is a rich history of exploration in the field of context-aware mobile music applications and services. A number of context-aware mobile 'apps' have explored dynamic accompaniment to sports and exercise routines, such as *TripleBeat* [10] and *Spotify Running* [20], which utilize playlists tagged with tempo metadata to match or lead a user's chosen level of exertion or cadence.

Lifetrack [17] describes a 'context-sensitive music engine' for mobile devices that drew on the contextual data of *space*, *time*, *kinesis*, *entropy*, and *weather* to control song *selection*. The system required users to tag their music collection with a set of corresponding system-defined labels such as music for daytime/night-time or for specific locations (defined by zip-codes). In our work we bring complementary foci to changes *within* individual tracks and to musical choices in adaptation.

Locative sound and music experiences [4, 11, 12] use location as a novel stage for music-based experiences where the user's role is also partly one of composer, as their spatial interactions shape the arrangement of the resultant soundtrack. Behrendt [2] proposes a number of categories for these experiences, for instance *sonified mobility* [11] that can be experienced anywhere, and *placed sound* experiences [4, 12], which are site specific and typically use GPS for positioning. Hazzard et al. [12] present the design and evaluation of a placed sound musical soundtrack to be listened to while visiting a sculpture park. Like the work presented here, the music is tied specifically to the location and changes dynamically as listeners move based on GPS. However, in that case original music was composed specifically for the experience, and adaptations were limited to fading particular tracks and stems in

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and out. Their approach also aims to support free exploration within a large physical area, while our focus is on defined routes and journeys.

2.2 Re-arranging Music

Music practice is littered with examples of 'fixed' musical arrangements being re-arranged or adapted. For instance, conductors of classical music regularly ignore the instructions in Mozart's scores and omit repeats of sections of his symphonies [14]. An electronic dance music DJ's whole job of work is to turn separate fixed linear recordings into a blended sequence [6]. Rubin et al. [18] propose a tool and process to enable the re-sequencing of segmented music tracks to generate scores to accompany audio stories. Wenner et al. [23] note the challenge of the real-time rescaling of audio that accompanies dynamic visual images, such as might be found in the video editing process or computer games. Their work explored an approach based on the feature extraction of a music track's structural segments with an accompanying algorithm to find the "least costly path" through a reshuffling of segments. These examples set a precedent for some of the adaptations of existing music that we consider here.

2.3 Interactive Audio

Interactive audio is found in a number of settings and many approaches to interactivity are used. Typically, large-scale musical arrangements are formed from smaller inter-changeable fragments that can be presented in different combinations and sequences. A common example can be found in computer games, where non-linear interactive soundtracks typically respond to the duration of gameplay by extending or reducing the number of segments of music (i.e. cells) and the phases of gameplay (e.g. periods of action or respite) by the vertical remixing of instrument layers (i.e. stems) [16]. The Infinite Jukebox web app uses beat recognition and feature matching to jump between beats in the song that are deemed similar. *Stems* [21] is an 'open multi-track' MP4 container format, that plays as a single 'mix' on standard software audio players, but when played on associated hardware systems the format contains separate elements that can be individually controlled. *Weav* [22] provides a player that allows for the adaptation of tempo that dynamically blends between different treatments or variants within the track to suit its changing 'energy'. The broadcast industry is currently engaged in creating 'object-based audio' broadcasts. *Responsive Radio* by the British Broadcasting Corporation (BBC) presents multiple readings of an online radio documentary in response to a listener's desired listening duration [1]. Our work does not propose such a format, but might be realized as a particular application of a sufficiently flexible format - a dynamic digital music object that could facilitate the assembly and rendering of novel locative experiences.

3. GEOTRACKS AND GEOLISTS

We propose two related concepts: *geotracks* and *geolists*. A *geotrack* is essentially a normal song or track which can be assigned to part of a journey or route; a *geoplaylist* (or simply *geolist*) is a set of geotracks to be used together for a *particular* journey. Aspects of the geotrack's playback and transitions between geotracks can then be influenced by the listener's progress, activity and context. For example, a dynamically selected subset of a track may be played so that the music reaches a suitable ending point when the listener reaches the end of a particular part of the journey.

At the level of a complete geolist of geotracks, the basic concept associates the music with a particular journey or part of a journey. Figure 1 illustrates the relationship between geotracks and geolists as part of a journey. Geotracks are chosen because they are in some sense appropriate to where they will be heard. For example, a musically dense track might fit a walk by a busy road, while a quieter and more reflective track might fit a walk across a park. Tracks might also be chosen and placed to reflect elements of their lyrics or mood, for example Money, by Pink Floyd, in the financial district. Tracks might also be chosen to reflect personal associations or memories.

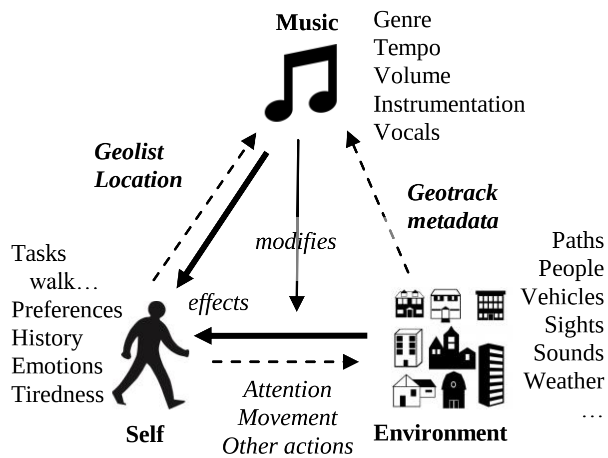

Figure 1. Geotrack experience framework

3.1 Prototype Player

We now briefly describe daoplayer[1], the prototype geotrack player application that we have developed. This is implemented as a native Android application as there are features which are not achievable with the Web Audio API. The current prototype loads and plays a single combined geolist file. This specifies all of the media (tracks and stems) for each geotrack, plus their associated metadata (e.g. specific locations to be associated with particular geotracks or adaptations) and dynamic behaviours, specified using JavaScript code fragments.

The geotrack player updates and adapts its playback once per second, as each new GPS location report is received. It uses the new GPS location to update its estimate of position and velocity. The *geolist* includes a specification of the intended route to be taken, which allows the player to estimate the user's position on the route, speed and time of arrival at waypoints. The scripts of the current geotrack can then be re-evaluated resulting in a new state for the audio engine, which specifies changes to the volume and exact playback point(s) of each audio track or stem over the next second or so. Scripts can also trigger a transition to a new part of the current geotrack or to a new geotrack.

4. EXAMPLE GEOLIST & GEOTRACKS

Having introduced the concept and technology of geotracks we now present an example of putting this approach to work in creating a walk, which also formed the basis of the user study we present in the next section.

The walk begins and ends at a building on an urban university campus. The outward journey of about 2.5km leaves the campus,

[1] https://github.com/cgreenhalgh/daoplayer

passes along and crosses a major road, continues along a quiet suburban street and enters the grounds of a stately home. Within the grounds the walk is along tree-lined pedestrian paths, and ends by climbing a small hill to the house itself. The return walk, also about 2.5km, descends the hill, follows a different set of tree-lined paths out of the grounds, re-crosses the major road, continues along a quiet suburban street to an alternative entrance into university campus, leading back to the starting point.

To accompany the walk we chose 6 tracks from *Medley DB* [3] and *The Open Multi-track Testbed* [9], which are open repositories of stereo mixes and multi-track stems held under Creative Commons licences. The tracks were chosen to deliberately offer a range of vocal 'pop / rock' styles at differing tempi and levels of intensity that were considered broadly accessible for most listeners.

4.1 Mapping the Music to the Walk

We view our selected playlist of tracks (geolist) as similar to film and computer game soundtracks, whose role is to support the narrative by setting context, regulating the mood and drawing attention to key visual events [8] via temporally congruent music [7]. In developing our methods of mapping track adaptations to the physical landscape we drew motivation from Hazzard et al.'s [12] work on soundtrack composition for a sculpture park. After study and reflection on the route to be walked along with previous pilot walks we identified 5 key considerations: (1) changes of course, such as a transition from one street to another represent the significant structural events in the walk; (2) the walker needs to negotiate junctions and other obstacles that may require attending to; (3) the walk contained a number of distinct environments (i.e. urban, residential, and parkland); (4) there are points of interest along the way that draw attention; (5) and finally that beginnings and endings, whilst on the surface appearing trivial, require careful planning.

We placed tracks along the route in relation to types of environment. We felt that upbeat music would be best suited for those urban busy areas, moderate intensity music for residential areas, and music of a lower intensity for the parkland. These choices aimed to match the character and the density of the built environment with the level of activity and density of orchestration within the music tracks. In response to our observations of the routes, we chose to introduce a new track at every significant *change of course* along the route. This dictated the number of tracks we used for the walk, as there were 6 of these key points along both the outward and return routes. For the *beginning* and *ending* of the walk we used two similar original pieces of instrumental music, a largely static musical texture with no melodic or rhythm content.

The brief gap typically found between songs on a playlist were removed wherever possible in favour of using cross-fades, so as to create a continuous, seamless soundtrack. This reflected our concept of geotracks being more like a soundtrack accompaniment for walks.

One of the main forms of adaptation employed was to dynamically extend or shorten the track depending on how soon the listener was likely to reach the end of the route assigned for that track. Sections (i.e. intro, verse, chorus) and subsections were semi-automatically determined. This deconstructed segmentation (cell) data could then be used by the dynamic scripts of the geotrack player. For instance cells could be looped, removed or sequentially re-arranged. Options to extend or shorten each track were specified in advance to the player, which can then select between them depending on the user's progress. For example, if a track required extending then it was deemed preferable to repeat an instrumental section, such as an 'intro' or failing that a chorus rather than a vocal verse. If a track required shortening then instrumental sections, verses and chorus, if multiple, were removed. Our approach shares some similarities to audio accompaniment for video [23] which explores methods of dynamically adjusting track length and re-ordering segments.

While most of the geotracks used a stereo mix, in two instances we used multi-track stems to enable dynamic remixing of the tracks. Typically the stems were sub-mixes (e.g. vocals, drums and guitars) produced from the larger number of individual tracks. The first of these multi-tracks treated the major road crossing, where all of the stems were reduced in volume but to differing amounts. This reduced intensity to allow the listener to focus on *negotiating the environment*, specifically traffic crossings. An adaptive mix of the second multi-tracks was used on transition from a residential area to a path in the park. Initially, only the vocal and piano stems can be heard while the path is tightly constrained. At the point where the fence-lined path opens up to reveal a view across the parkland, the remaining stems fade in (an example of adaptation to suit a scenic *point of interest*).

5. STUDY

We evaluated the geotracks prototype described above using a naturalistic experiment. Each participant undertook the same circular walk described above. While walking they listened on headphones to music from a smart phone, generated by the geotrack player. During one half of each participant's journey they heard geotracks, i.e., the music adapted dynamically. On the other half of the journey they heard a fixed playlist comprising the same songs. There were two conditions: adaptive music on the outward journey (fixed playlist on the return); and fixed playlist on the outward journey (adaptive music on the return). Participants were not informed about the two conditions or the adaptive functionality of geotracks. Rather, they were simply asked to walk the defined route whilst listening to some accompanying music. Participants were asked to complete a short questionnaire twice, first at the halfway point on arrival at the stately home, second on their return to campus at the end of the walk. The participants then had a semi-structured interview lasting around 15 minutes. Participants were recruited from the local area via e-mail, poster advertisements and snowballing. A total of 28 participants completed the walk, consisting of 12 males and 16 females. Participants were randomly allocated to conditions, balancing gender between conditions.

5.1 Results

Participants' subjective ratings in the questionnaires[2] at the end of each leg of the walk used a 7-point Likert scale (with associated ordinal values) ranging from *entirely agree* (1) through *neither agree nor disagree* (4) to *entirely disagree* (7). Results were analysed using the nparLD [15] package for nonparametric analysis (parametric tests being unsuitable for individual Likert items). Significance results are nparLD's non-parametric ANOVA-Type Statistics.

Considering statement 1, "I enjoyed the walk", all participants enjoyed both walks to some extent (median: 2, mostly agree).

[2] Anonymised data available: http://dx.doi.org/10.17639/nott.50

Overall participants enjoyed the adaptive leg of the walk more than the non-adaptive leg (p=0.044, statistic=4.04, df=1), which was largely due to differences in the return walk, with relative treatment effects of 0.39 (return, adaptive) and 0.67 (return, fixed) (for reference, an effect size of 0.2 is often considered to be "small" but significant). Participants also preferred the return-adaptive condition (p=0.024, statistic=5.06, df=1), with relative treatment effects of 0.58 (out adaptive) and 0.42 (return adaptive).

Considering statement 2, "I enjoyed the music", 26 out of 28 participants enjoyed the music to some extent (median, mostly agree (2)). Participants enjoyed the music more on the outward journey than on the return journey (p=0.046, statistic=4.00, df=1), relative treatment effects 0.45 (out) and 0.55 (return). Participants also enjoyed the music marginally more in the return-adaptive condition (p=0.073, statistic=3.21, df=1).

Considering statement 3, "The music enhanced the walk", most participants reported that the music enhanced the walk (median, mostly agree (2)). The music was reported to enhance the walk significantly more on the outward journey than on the return journey (p=0.0043, statistic=8.14, df=1), relative treatment effects 0.42 (out) and 0.58 (return). The different between conditions was not significant.

Considering statement 5, "Changes in the music complemented changes in the walk", the median response was somewhat agree (3). Overall, changes in the adaptive music complemented changes in the walk more than changes in the non-adaptive music (p=0.000036, Statistic=17.04, df=1).

5.2 Discussion

Based on feedback, all participants enjoyed the walk. Most enjoyed the music and most felt that it enhanced the walk irrespective of whether the music was adaptive or not.

Participants *enjoyed the walk* more on the leg with the adaptive music than with the non-adaptive music. Participants also report that *changes* in the music complement changes in the walk more with the adaptive music than with the non-adaptive music. This seems to match comments made by many participants about whether the music 'fitted', or was 'appropriate' for particular stages of the walk: "*If the music fitted the surroundings it really complemented the experience but had the opposite effect if not"*. The 'fit' of the music to the walking activity was also influenced by its tempo for some.

Participants *enjoyed the music* more on the outward leg than on the return leg (ignoring adaptation), and also report that the music *enhances* the walk more on the outward leg than on the return leg. In part this appears to be due to the novelty of the music on the outward leg; on the return leg the same songs were repeated (albeit in a different order) and this was largely noted with disappointment. At least for some people, the return leg also *"felt as though I was returning to normal life"*. A lack of 'fit' may account in part for people enjoying the music least on the non-adaptive return journey. Two participants highlighted the incongruence between the fixed playlist, which starts with two high intensity tracks, and that part of walk from the stately home along a tree-lined avenue. However some participants appreciated the higher-energy tracks within the park environment.

Considering only the return leg of the journey, participants *enjoyed the walk* more and *enjoyed the music* marginally more with the adaptive music than with the non-adaptive music. Considering only the outward leg, participants enjoyed the walk the same with or without adaptive music, enjoyed the adaptive music marginally less and felt that it did not complement the walk as much as the fixed playlist. While some participants commented positively about certain transitions, a small number of participants reported that some transitions were 'clunky' or otherwise disruptive, and two participants were disappointed when specific tracks were 'cut off' before the end as a result of passing a transition point. One participant reported hearing "glitches" in a track, which probably correspond to jumps between sections of a track, and two noted hearing repetitions within a track on the adaptive leg. These issues may help to explain why on the outward leg of the walk, participants felt that the adaptive music enhanced the walk less than the non-adaptive music, and why some enjoyed the non-adaptive music more.

As described, two tracks were remixed on the fly from multi-track versions. The first reduced the volume and cut out some stems on approach to the pedestrian crossing. Two participants specifically noticed and appreciated this adaptation while three participants commented negatively about negotiating the pedestrian crossing with the non-adaptive music, where the chosen track presented a loud and dense texture at this point.

6. CONCLUSIONS AND FUTURE WORK

We have found that the basic geotrack concept is sound, i.e. that geo-locating the playlist can enhance the walking journey. This seems to be primarily as a result of increasing the 'fit' or appropriateness of the music to particular stages of the journey. There is also evidence that the multi-track adaptations can yield practical and experiential value for at least some participants, e.g. easing the use of crossings or enhancing elements in the environment at particular points. However there are still challenges to the execution of sensitive and musical adaptations of existing musical arrangements that require further work. It would also be beneficial to test the generalisability of these results to other journeys and choices of music. For example, many participants had a strong preference for particular genres, artists or songs of their own selection. This in turn raises the question of how people would feel about the adaptation of songs they are familiar with: whether breaking their expectations of a track's arrangement would disrupt any benefit gained from 'fitting' with a journey segment.

More broadly, we would like to extend this work to include other triggers for adaptation in addition to location. For example, participants' reported that their experiences were affected by: the weather (sunshine, temperature, wind); the season; the time of day and day of week; ambient noise (traffic and people); road-works; other people and animals nearby. Considering a broader range of contextual factors would also combine naturally with automating the *choice* of tracks (e.g. as in [17]), in addition to adaptation within tracks and transitions. In turn, this would require more automated support for creating geotracks and geolists, whether as part of a human-led authoring process or perhaps even an entirely automatic process.

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