GoingPublik: *Using Realtime Global Score Synthesis*

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ABSTRACT
This paper takes the reader through various elements of the *GoingPublik* sound artwork for distributive ensemble and introduces the Realtime Score Synthesis tool (RSS) used as a controller in the work. The collaboration between artists and scientists, details concerning the experimental hardware and software, and new theories of sound art are briefly explained and illustrated. The scope of this project is too broad to be fully covered in this paper, therefore the selection of topics made attempts to draw attention to the work itself and balance theory with practice.

Keywords
Mobile Multimedia, Wearable Computers, Score Synthesis, Sound Art, System Research, HCIs

1. INTRODUCTION
The core idea behind the work is a strategy of mobility employing a wearable computer system running a software based electronic scoring system. The score itself basically allows for what might be termed 'composed improvisation' which permits improvisational elements within a compositional structure. By electronically monitoring the performer's physical positions during performance using universal inputs such as geographical positions obtained via satellites and sensors using the earth's magnetic field, the score makes suggestions and demands on the performer to various degrees and at various times.

The score's contents are clearly then linked directly to the movements of the performer, thus creating a unique choreographic metaphor of sound dispersing in space. The compositional quantities and qualities of the work are thereby based on spatial mobility, and intensity of form is held by changes in timbre and rhythmic modulations brought about in conjunction with the sound distribution. Two versions of the work exist, one for closed performances spaces and another for open performance spaces. Both versions network the performers in such a manner, that the electronic scoring becomes self-regulating. The performers are thus truly ‚hands free' and are able to react to other ensemble members and to interact with the performance space.

2. SYSTEM HARD- & SOFTWARE
The system hardware in its current form comprises a StrongARM/XScale based proprietary wearable controller (Q-bic)[1], a custom made micro programmed 3D compass sensor, a Garmin GPS device, and an MicroOptical SV-6 head-mounted display. The resulting interconnect is depicted in Figure 1. A noteworthy detail is the use of a simplified datagram-based layer of the standard Bluetooth protocol to connect the compass sensor and the wearable controller.

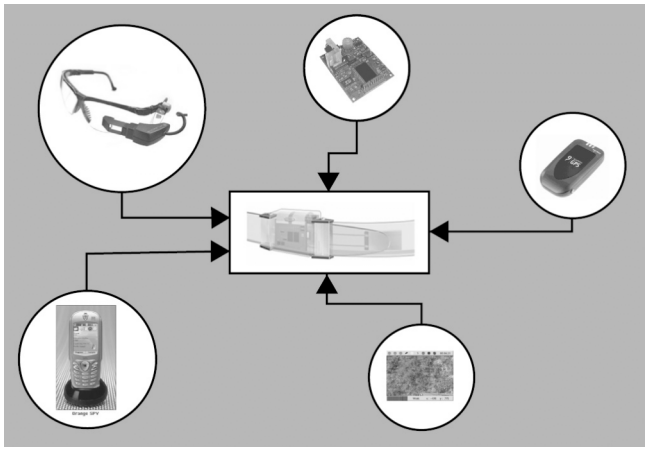

Figure 1. The Q-bic is depicted at the center. From the top left and clockwise are the display glasses, the 3d Compass, the GPS device, a screenshot and the SmartPhone interface.

The main tasks of the wearable controller is reading the sensor data and computing the score in real time according to predefined rules. The scoring application is programmed in a Pascal-like language called Active Oberon[2]. It runs on Bluebottle, a proprietary and ultra-lean system kernel enhanced by a highly efficient 2.5D graphics engine that supports sophisticated visual effects on the basis of general-purpose hardware. The Wearable Lab at ETH Zurich (Q-bic), MASC UK (3D compass), the Runtime Systems group at ETH Zurich (Bluebottle) and Art Clay, the

sound artist were actively involved in the technical design and the development of this system. The trombonist, Günter Heinz tested the prototype systems.

3. THE ELECTRONIC SCORE

3.1 The Modulating Matrix

One of the most innovative aspects of *GoingPublik* is its use of an electronic score. The "pages" of the score get "turned" dependent on the behavior of the performer and its contents change in relationship to the performer's position within the performance space. The basis of the score is a „modulating matrix" constructed out of a series of vertical and horizontal lines. It enables non-rational elements in the environment to be interpreted as rational elements of a notation system for sound. How the matrix modulates, or changes its resolution, is, determined by the performer's position within the performance space. The position is obtained by referencing the Global Positioning System (GPS). After receiving the GPS satellite code, it is parsed and given further as x, y value pairs that reference the position as coordinates within a predefined area. By moving within this area, the performer influences the position of the matrix's lines, therefore continuously adjusting the 'resolution' of it to parameterize sonic domains of frequency and time. For use during 'inside' performances and in the case of GPS signal fallout, a conditional location simulator has been implemented.

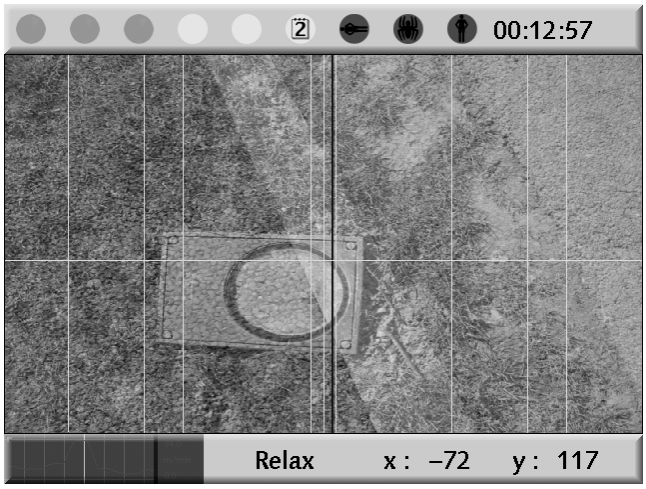

Figure 2: A screen shot of the score window showing the matrix, image for east, conduction-line, the Go, Stop and Mod action icons, and additional information for the user.

The matrix consists of 'Range-Lines' moving on the horizontal plane in relation to the performer's coordinates on the North-South axis and 'Time-Lines' moving on the vertical plane in relation to the performer's coordinates on the West-East axis. Both line systems move independently from one another and are based on separate algorithms, which generate and manipulate the lines in real-time in a predefined way as the performers change their positions in terms of heading and distance traveled. There is a maximum of nine Time-Lines, which in turn designate seven rhythmic spaces. The contrary movement of the Time-Lines away from one another, brought about by the performers' movements, modulates the spaces between equidistant and non-equidistant states. A 'Conduction-Line' travels through the matrix from left to right and facilitates score reading. The time taken by the Conduction-Line to scan through the space between two Time-Lines is always a constant value in milliseconds. The constant is however dependent on the walking speed of the performer measured in meters per minute. There are four discrete tempo settings: Rest, Relax, Work and Hurry. The speed of the Conduction-Line as it travels through the rhythmic space therefore makes a quantitative difference in the amount of time the performers may 'stay' on an area of the score image. The whole matrix system works then in conjunction as a variable space-time notation concept for determining rhythm and tonal content.

The movement of the Range-Lines, in contrast to that of the Time-Lines, brings about equidistant spaces. There is a maximum of six Range-Lines, which in turn designate seven range spaces. These spaces indicate the ranges available to the performer, limiting and expanding the instrumental range as the performer changes position within the performance space. If all of the Range-Lines are present in the matrix window, seven range spaces are indicated. Ordered from bottom to top the available ranges would be as follows: Outside, Very Low, Low, Middle, High, Very High and Outside. Regardless of number of ranges, they are always kept in consecutive order, the performers freely choosing the lowest initial range first and then continue upward from there. The performers also decide what is meant by 'outside' the instrument and where the boundaries the instrumental ranges are.

3.2 Directional Imaging

The score image chosen over which the lines form a matrix is drawn from a library of four images. Each score image has been assigned one of four directions (N., E., S. & W.). The compass measures the heading of the performer with 360 degrees of resolution. However, a discrete reading of only eight possible 'headings' is used. The heading value determines which score image is to be seen. Single score images are rendered at the poles of the compass and the score images superimpose at positions between these poles. In addition to heading, the compass also measures 'pitch' (forward and backward tilt) and 'roll' (side to side tilt). These values are used to distort the score image present in order to create 'variations' on that score image. The degree and direction of the distortion is directly proportional to these values: The larger the intensity of pitch and roll is, the greater the distortion of the score image will be.

The size of the displayed score image is dependent on the quality of the performer's walking activity measured by calculating out an average speed using the GPS over a given period of time. If the performer is 'standing' more than 'walking', the image will enlarge up to 200% of its original size; if the performer is 'walking' more than 'standing', the image will shrink back to its original size. The walking speed of the performer is then not only reflected in the tempo of the Conduction-Line but also in graphic material contained in the score through changes in size. The score image is then 'studied' by the performer in conjunction with the modulation of the matrix. Variations in sound material not only arise due to the distortion and the size of the score image but also arise on

account of the differences in space between any two Time-Lines as the Conduction-Line passes over.

3.3 The Action Icons

Apart from the parameterization carried out by the domains of the matrix, the system provides the performer with a second set of compositional methods by suggesting and even sometimes demanding certain actions. These 'hints' are in the form of three groups of icons of three each, which are located above the score along the information bar. Depending on the performer's walking speed, the time spent doing so, and a random component, the green 'Go-Icon' and the red 'Stop-Icon' groups suggest and if ignored demand speed-ups or slow-downs. Related performative actions are associated with each of the icons in order to artistically integrate changes in walking activity, regulate the tempo between performers in general and to integrate the performer's sonically into the environment.

In addition to the two icon groups mentioned above, there is a third group of icons. Based on the rate of heading change, walking speed and a random component, the 'Mod-Icons' suggest or demand by their appearance in the information bar how the score is to be read through. Here, an algorithm is used to set up an equation between walking activity of the performer to the interpretation of the score. This equation was determined by borrowing aesthetic concepts of stone paths in Japanese gardens. It was possible to generate and control parameters of 'style' by drawing a parallel between reading through a score and walking on a stone path, These parameters are PHRASE (the division of the matrix into units of material), PATH (the form of the curve used to read through the matrix) and PLAY (the degree of density in playing while reading through the matrix). Here the movement of the eye over the image from left to right through the matrix system is confined by the above series of phrasing rules. By reading through the score in this manner, contrapuntal differences between the performers are brought about, so that 'sonic windowing' is created through which unoccupied audio space and variation in voice density are guaranteed.

4. THE DISTRIBUTIVE ENSEMBLE

4.1 Distribution

There are several concepts inherent in sound art works that make them different from music compositions. The difference being that music is defined by creating structures based on the relationship between sounds and sound art by placing emphasis on the beauty of the sounds themselves. Since John Cage many artists have used alternative methods outside of the realms of harmony to create structure and to unite large musical forces. Sound artists seem more interested in seeking new ways to shape rather than control musical forces, whether this is a group of musicians or a rack of machines.

In *GoingPublik* this is accomplished through a theory of 'distribution', which creates structure by computer tracked choreographed movement. This is made possible and accomplished as follows: Each performer is equipped with the same electronic scoring system and the system revolves around universally shared inputs. All of the systems have therefore a common denominator and are thereby virtually linked. So, despite the physical distribution of the performers in space, it is possible to have commonly shared elements which can be structurally exploited. For example, at moments of close proximity between performers synchronized group movements such as rotation bring about synchronized changes of score images. Sonic 'tutti' elements are therefore easily obtainable. Further aspects of this are discussed in part in section 4.3.

4.2 Performance Modes

There are two performance modes offered by the software: An 'inside' mode is for closed spaces such as a museum and an 'outside' mode is for open spaces such as a city. For an 'inside' performance the performers dismantle their instruments and spread the parts across the performance space. This action emphasizes the effect of distribution visually and creates a predetermined task that results in a predictable choreography of movements. The system sensors respond accordingly, and the electronic score changes in conjunction to all movements made as the performers re-assemble their instruments.

Figure 3. Günter Heinz testing a prototype of the Realtime Scoring System (RSS) during a test performance at Irchel Park located in Zurich, Switzerland.

For an 'outside' performance three routes, one for each of the performers, are roughly designated. The performers follow the routes and because the action icons regulate walking tempo, the performers tend to meet when their routes overlap. The overlapping of the routes guarantees that the scores will 'engage' as the performers make their way through the city's streets because the performer's position within the city determines the formation of the score. The greater the distance between the performers, the more varied their scores will appear; the lesser the distance between them, the more similar their scores will appear. So, when the separation between the performers diminishes as they come to meet at a crossing, their scores will slowly grow in similarity in a unique way until each score has the exact same matrix formation. Therefore all performers have at times the exact same parameter structure and at other times a completely different one.

4.3 Structure & Synchronization

The movements made by the ensemble players can be understood as choreographic patterns having an internal system of counterpoint: 'bundled movements', or synchronized movements made together are analog to polyphony in similar motion and 'free movement' or non synchronized movement carried out in non-relationship to one another are analog to contrary motion. Further, a parallel can be drawn between the distribution amount of the performers and the degree of 'dissonance' in terms of rhythmic and range discord existing between them.

The dispersion of musical forces brings along with it conflicts in synchronizing. However, since the systems used in *GoingPublik* are virtually linked despite physical distribution a unique solution has been found. One can refer to two types of synchronization used in the work. These are termed 'local' and 'global' synchronization. Local synchronization is made possible by the 3d compasses and takes place when performers change heading at the same time and to the same degree, thus changing the score image at exactly the same time. Global synchronization is made possible via GPS and takes place when performers explore matrix similarities, for example by narrowing the distance between them, thus bringing about corresponding matrix resolutions.

The synchronization of the shared palette of images and the synchronization of the matrix lines, both obtained by spatial movement, have proven to be the most important aspect for creating sonic structure within the work.

5. RELATED WORK

GoingPublik embraces aspects of mobile art, mobile music, wearable computing, ubiquitous sensor networks and real-time image manipulation. The following projects are relevant to *GoingPublik*.

"Instant Gain in Grace" by Irena Kulka is an interactive dance project. It uses a wearable sensor network for motion analysis which translates rhythmic-dynamic and postural expression into visually emotional space. The project comes demonstrates an intuitive encounter with limitations of technology by having human interaction internalize 'machine structure'.[3]

"VJ-Fleet (DUB)" by Julie Andreyev investigates public space as a mobile tableaux. Locative audio and video are interwoven with aspects borrowed from popular car and club cultures. Serving as hybrid forms, customized cars equipped with interactive audio and video technologies and panoramic video projections on the cars' windows cruise the city seeking engagement as urban performance [4].

Further related work can be found in [5] and [6].

6. EVALUATION

The project stands as a record of a collaborative partnership between practitioners from different backgrounds. Critical points in the creative process between artist and scientists occurred when a team member had to 'cross over' into a domain not their own, thus being forced to share and to acquire new knowledge. The tool fostered cognitive processes that resulted in developing creativity. Therefore, it could be employed as an aid in developing skills for improvisation and as also a study tool for researching such processes.[7]

In the opinions of the performers, the work's premier confirmed everything that had been thought out and trialed at rehearsals. The interpreters' capabilities were well exploited by involving them in the decision-making process. The optimum condition for working with new ‚mixed' forms was thus created and there seemed to be no oppositions between composing and improvising. In *GoingPublik* they simply co-exist at two different levels; it is the interpretation of the work that made them function together. This approach typifies "instant composing" which expands on formal jazz principles by using structures found in contemporary composition.

The final conclusion made by the sound artist was that not only were the performers coaxed by the tool to bring about something new, but by attempting to bridge a gap between 'composition' and improvisation', he too was brought into unexplored territories of mobile art and music.[8]

7. ACKNOWLEDGEMENTS

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