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Abstract
In this paper we propose an interactive visualization technique *QS Spiral* that aims to capture the periodic properties of quantified self data and let the user explore those recurring patterns. The approach is based on time-series data visualized as a spiral structure. The interactivity includes the possibility of varying the time span and the time frame shown, allowing for different levels of detail and the discoverability of repetitive patterns in the data on multiple scales. We illustrate the capabilities of the visualization technique using two quantified self data sets involving self-tracking of geolocation and physical activity respectively.

Author Keywords
Quantified Self, Personal Informatics, Time-Series Data, Data Visualization, Periodic Events

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction
Recently self-tracking has gained increased attention and uptake with the availability of smartphones and low cost

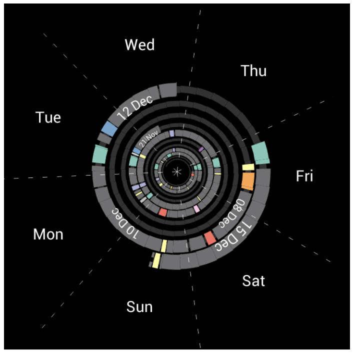

Figure 1: The QS Spiral interactive visualization with color coded data points shown on a time spiral in a 7-day view.

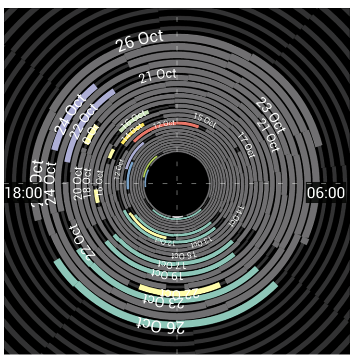

Figure 2: In this configuration the time scale of the QS Spiral is shorter and more details are shown in a 24-hour view.

wearable devices, such as, FitBit[1], Basis[2], and Zeo[3]. These devices are gradually lowering the barrier for people to engage in self-tracking and lifelogging. As suggested by Li et al.[4], self-reflection is an essential part of personal informatics. Self-reflection can be facilitated through data visualization enabling the user to interact with the collected data to receive feedback on self-tracking and to be guided in understanding of behavioral patterns. Different approaches to visualization of quantified self data has been proposed, ranging from traditional statistical charts to abstract art[4].

An inherent property of lifelog self-tracking data is the periodic properties of the data with patterns on different temporal scales including days, weeks, months, and years. Moreover self-tracking data may potentially be characterized as multi-dimensional depending on the number of signals being tracked. Our motivation is to create an interactive visualization that captures these specific properties of quantified self data. Thus in this paper we propose the data visualization approach *QS Spiral* that aims to capture both the continuity and periodic properties of quantified self data by introducing visualization of time-series data on a spiral, enabling the user to interact with and interpret the data through simple touch-based gestures.

Related Work

In visualization of lifelogging and quantified self time series data traditional charts have been the norm, but several other approaches have been proposed to enable easier and faster perception and exploration. For instance physical activity indicated by the growth of a flower on the FitBit wearable device, but also abstract visualizations or avatars have been proposed. While visualization of time-series data in a spiral structure has been proposed in [3], [5], and [6] visualization of quantified self data is novel. Although Spark[2] is an example where abstract representations of physical activity data include configurations with a spiral structure and concentric circles of data points, this visualization is fairly abstract and aimed as ambient art, and does not communicate details nor periodic events.

QS Spiral

Our proposed visualization technique is shown in Figure 1 and 2 and builds on top of a clock-dial metaphor with a circle corresponding to a time span (hour, day, week, or year). The continuity of the time series is captured by the continuous spiral timeline, with the present in the outer ring, and the past towards the center. In the present configurations one full circle represents 24 hours or 7 days as shown, and the spiral is logarithmic with the distance between each turn decreasing in geometric progression. This way the outer arcs are thicker, and become progressively thinner as they approach the center, so that most space is allocated for information in the outer ring, representing the most recent time frame. The start- and end time of each event are converted to angles and the corresponding arc is drawn on the spiral. Data points can be shown using different color coding of the timeline as well as symbols or even animations. Depending on the amount of information that needs to be embedded per time frame, the thickness of the timeline can be varied by zooming in or out. Thin lines optimizes the visualization for overview and discovery of patterns on longer time frames whereas thick lines optimizes the visualization for details on a shorter time frame. For navigational support an overlay with time of the day or day of the week is

[1]http://www.fitbit.com
[2]http://www.mybasis.com
[3]http://www.myzeo.com
[4]The work of Laurie Frick is a good example of art based on self-tracking data sets http://www.lauriefrick.com/

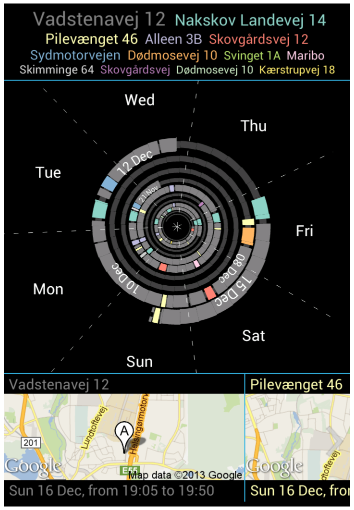

Figure 3: A week view showing the geolocation data captured over a 4 month duration. A tag cloud of color-coded geolocations are shown at the top and a timeline of map segments at the bottom. Tapping the map segments will highlight those geolocations in the spiral.

added on top of the spiral.

Prototype

We have built a prototype of the *QS Spiral* visualization for Android smartphones enabling us to experiment with touch-based interfaces as the basis for the interactive visualization. The single tap gesture allows the user to highlight specific data elements. A pinch gesture allow the user to zoom into a particular part of the data and swipe gestures allow to pan, resulting in a zoomable map metaphor. The double-tap gesture switches between different time views. The combination of these gestures allow to focus into the details of a specific period, or provide overview of a larger time frame.

Case Studies

To demonstrate the capabilities of the interactive visualization we have experimented with different types of quantified self data sets. Two data sets are used to illustrate the capabilities of visualizing and interacting with quantified self data, and in particular to discover periodic trends inherent in the data.

Geolocation Self-Tracking Data

In the first example we use geolocation data captured with sensing software on an Android smartphone[1]. The software continuously acquire and log data from the embedded location sensors (GPS and WiFi). From the location data, static locations are extracted according to movement speed and grouped into logical groups using the DBSCAN clustering algorithm. The data was captured over a duration of 4 months. A screenshot from the interactive visualization is shown in Figure 3. In this interactive visualization the display is separated in three parts with the *QS Spiral* in the center. On the top is a tag cloud showing the most frequently visited places in colors corresponding to the colors shown in the spiral. The bottom of the display contains time series of places with map segments showing the places visited. When the user taps a visited place the corresponding places will be highlighted in the spiral.

Physical Activity Self-Tracking Data

The second example data set contains physical activity data captured using the FitBit step counter for a duration of 12 months. A screenshot from the interactive visualization is shown in Figure 4. In this interactive visualization the display is separated in two parts with the spiral in the center showing the physical activity level measured in number of steps color coded with color intensity corresponding to the number of steps taken in that time frame, as indicated by the legend shown at the top.

Discussion

The interactive visualization facilitates exploratory data analysis and helps identify periodic patterns. In both cases we found that that periodic events and the daily/weekly rhythms were discoverable using the *QS Spiral* visualization, but also that the repetitive nature of the data makes deviations stand out clearly. The spiral visualization represents events with similar period aligned along similar angles of the arcs, resulting in aligned sections of the spiral. Moreover, the color coding of events highlights the relation between groups of events. The combination of angle and color allows one to explore patterns of events "at a glance". As examples using the interactive visualization of geolocation data we discovered two distinct periodic patterns during (9am to 3pm and 7pm to 10pm). In addition patterns on Mondays and Wednesdays, and a pattern on Tuesdays and Fridays were found. Events with the same color belonging to the same

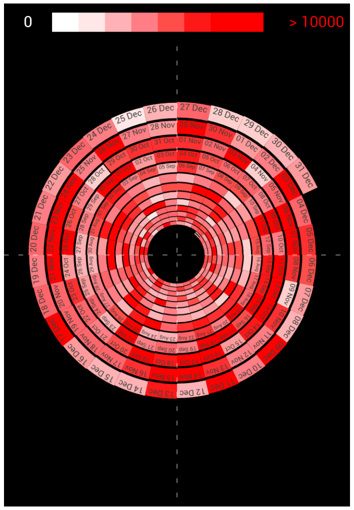

Figure 4: A four week view showing physical activity data captured over a 12 month duration, with the color density corresponding to the number of steps taken daily.

region but with different duration signal an irregularity in duration. Events not in the same region as others with the same color signal an irregularity in a periodic occurrence, and isolated events are easily discovered too. Also the choice of the scale of period changes the perception of periodicity, where a period of 24 hours highlights patterns for events happening in the same time of the day, while a period of 7 days highlights events happening in the same day of the week. In the interactive visualization of physical activity repetitive patterns were found indicating lower activity levels during weekends compared to week days. Also higher activity levels were discovered in the last quarter of the year.

In the present data sets, the 00:00am–06:00am hour time period is almost empty meaning that a substantial part of the visualization area is unutilized. Integration of multiple data sets including geolocation, physical activity, sleep, calendar data and other personal information data sources with temporal properties could utilize the full space and allow the user to discover correlations between different quantified self data streams. To make quantified self data useful a large volume of data needs to be easily accessible, so that rhythms and progress can be monitored. An interactive visualization is essential to engage users by providing feedback at a glance and the *QS Spiral* is considered a compact representation that fits on a small accessible display such as a smartphone display or even a wearable/wrist-worn (self-tracking) device. Future work include experiments with additional self-tracking data sets (with different resolution) and variations of interface configurations (such as distortions and animations) and to further explore the design language to map touch gestures to navigation of the interactive visualization.

Conclusions

We have presented *QS Spiral* as an approach to visualize and explore quantified self data with the aim for users to discover patterns and the periodic properties of the data. The visualization has been demonstrated with geolocation and physical activity self-tracking data sets.

Acknowledgments

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