GeoPoke: Rotational Mechanical Systems Metaphor for Embodied Geosocial Interaction

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ABSTRACT

Rotational dynamic system models can be used to enrich tightly-coupled, bearing-aware embodied control of movement-sensitive mobile devices and support a more bidirectional, negotiated style of interaction. A simulated rotational spring system is used to provide natural eyes-free feedback in both the audio and haptic channels in a geosocial mobile networking context.

Categories and Subject Descriptors

H.5.2 [**User Interfaces:**]: Haptic I/O

Keywords

Rotational dynamics, tilt-input, vibrotactile, accelerometer, multimodal, mobile, mobile spatial interaction

1. INTRODUCTION

We present the use of pointing style gestures for a more embodied style of interaction digitally bridging the gap with others in mobile social networks. Using a mechanical systems metaphor driven by signals from inertial sensors, we provide an adaptable and highly flexible means for users to interact with and probe or *poke* friends in their social network for information relating to their current state (status, location or current movements, for example) as illustrated in figure 1.

Social networking has expanded off of the desktop into the mobile world. A number of mobile, location-aware social applications enable users to communicate via regularly updated location or context information that offers a richer sense of the dynamics within a social group or an individual user's life, but still do not take full advantage of this new mobile context. Limitless data plans, devices such as the Nokia 6210 equipped with magnetometers, for compass heading, accelerometers, for device orientation, and location-aware technology create the possibility of bearing-aware interaction that provides a much more rich and embodied experience to the users of mobile geosocial applications.

One issue that routinely emerges from this kind of application is privacy. How do users choose to display or hide their current location or availability in a flexible way that does not hinder this more embodied style of interaction? Dynamic models can act as a mediating mechanism which enables users to maintain their privacy if desired.

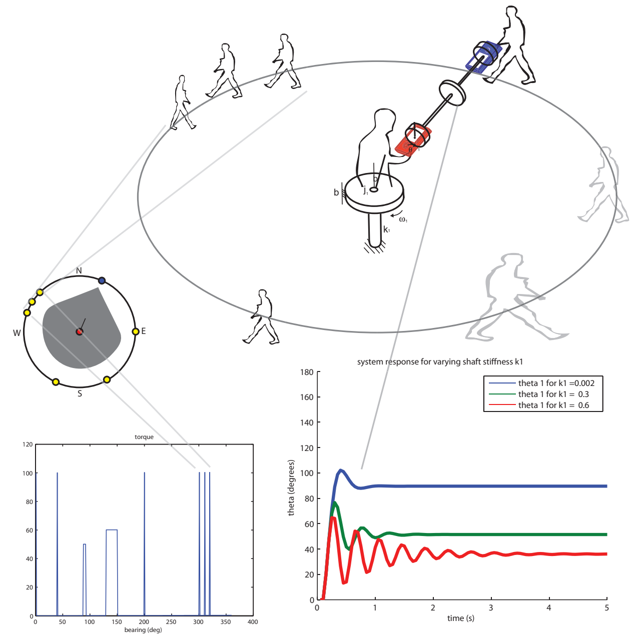

Figure 1: Scanning to find the direction of friends is represented by a single disk metaphor and sensed via a non-linear friction function with the bearing of each user represented by a spike in the torque caused by higher friction at that point. A more informative level of interaction takes place with a selected individual using a 'twisting disks' metaphor. The twisting of the device, sensed using accelerometers, has an effect on a mediating disk (depending on the parameters) that is perceived by the other user.

2. MOBILE SOCIAL NETWORKING

Mobile social networking occurs in personalised virtual communities of friends and associates and many of the well established web-based social networks now feature a mobile component that allows users to stay connected while on the move. Micro-blogging applications such as Twitter[13] and Jaiku[5], for example, are services that enable users to send status updates to a server where they are displayed on a profile page for other members of the social network to view. While these applications do allow users to update their current location manually, no active location tracking takes place.

Location-aware social networking allows the active tracking of

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a group's location by GPS or other location tracking technologies. Some recent research has been conducted on this kind of so called 'geosocial networking' application. The *Whereabouts Clock* [10] has shown that even with relatively low-resolution location updates (on the level of 'home' or 'work'), that this kind of location-awareness amongst a group can help foster a sense of belonging to that group. Similarly, Barkhuus *et al* [1] have shown that this kind of system can become a tool that moves beyond simple group awareness via location updates to something that encourages "the ongoing 'story' of conversations within the group". There are also now a number of commercial geosocial networking applications on the market [6, 9] but these are by and large still restricted to static text message based state updates with no real active engagement with the local environment or with nearby friends.

3. GEOPOKE

The gpsTunes[12] system represented the first steps in providing an embodied location-aware application. This enabled the navigation to and interaction with static geotagged information placed in the fused digital/physical world. The extension to geosocial interaction with other users is the next step. With the system described in this paper, users have the ability to gauge the general direction of their friends by simply scanning the horizon using heading data from a magnetic compass and knowledge of the locations of all members of their social network to calculate a bearing. Care has to be taken with the treatment of uncertainties in both the GPS estimates and in the estimates from our sensors, which can place significant limitations on this kind of interaction as discussed in [11].

Twisting actions, sensed via accelerometers, allow the user to probe for a response and feel, via audio and tactile feedback, the current state of the other user. Twisting is also a natural metaphor for 'turning back time' to listen to a rapid 'replay' of recent activity in another user's activity. An active response to this twisting action, could, for example, mean that they are available for a call (some people might choose to not call someone based on this response, as discussed in [1]). Users can sense that someone is probing their device and can choose to respond positively or negatively by tightening up the system. A deliberate rejection of a call may cause strain in a friendship that is avoided with this kind of mediation, taking advantage of the natural ambiguity of this kind of continuous signal and helping to preserve a users privacy. Did the person deliberately reject my poke? Or do they just have a bad signal at the moment? This kind of interaction is analogous to the nudge or poke features in instant messenger applications but has the potential to provide far more finely nuanced information.

4. SCENARIO

John is walking through the centre of the city and decides to check if any of his friends are around. He makes a quick scan with his mobile device towards the area of bars and cafés and finds two or three people in that area. Andy is one of those people discovered so John decides to investigate further to see if Andy is free and if it is possible to join him. He points in the direction of Andy for a second and an initial connection is formed between the two devices. With a quick flick or twist of his device John receives very little response from Andy, giving him the impression that Andy is not really available or that he does not have a very good position fix/signal and may not really be in that area anyway. John then decides to try someone else.

Andy has a date at a bar and gets there a bit early. While he is waiting he feels a probing connection to his phone, he checks the screen and it is John. This is a difficult situation because he does not really want John to come and interrupt his date (or even find out that he has a date) but he equally doesn't want to offend John, so he simply chooses not to engage with this poke from John which causes the underlying mechanical system to slowly adapt to his lack of attention and become less responsive as illustrated in figure 4(a). Then Andy feels another connection to his phone and this time it's his date. He turns his device to face the direction of her device and engages causing the system to dynamically adapt and the connection to become much more responsive as illustrated in figure 4(b). After a few flirtatious exchanges (figure 4(c)), Andy now knows she's on her way and she knows he's already waiting.

5. PRIVACY ISSUES

A recurring issue with this kind of system, especially the more active and constantly updated location-aware services is that of user privacy. The sharing of location is a sensitive issue for most users who, according to [4] in their initial formative study, want to keep their location visible to certain groups of people (close friends and family) but not visible for other groups of people (employers or work colleagues). Barkhuus [2] found that location-tracking services have the potential for success if users are able to switch it off again indicating perhaps that users must be empowered with some sense of control with this kind of system. Palen and Dourish [8] argue that "privacy management is a dynamic response to circumstance rather than a static enforcement of rules". They describe the dynamic process to be under "continuous negotiation", a process of give and take and they provide examples where disclosing information is sometimes necessary to gain privacy. This indicates that we should construct a suitably adaptable and controllable system that can respond in a dynamic way to the user's circumstances.

With our approach of providing a mediating mechanism in the virtual environment this allows us to create a proxy for the current status of the person with whom we are attempting to create a dialogue. One problem though is how do you provide a mechanism which is simple enough to convey meaningful information, but dynamic enough to be adapted to certain situations? A rotational mechanical systems metaphor provides a convenient and dynamic method to create a mediating mechanism between two users. The parameters of this dynamic system respond to circumstance and such 'circumstances' could be the user's current status, the current quality of the position estimate, the time of day, that specific location or the users current mood desire for privacy, for example.

6. ROTATIONAL MECHANICAL SYSTEMS

Our interaction mechanism takes the simulation of a rotational dynamic system driven by twisting motions from a mobile device to facilitate and enrich interaction in the kind of scenario described above. The intention in using a tangible physical metaphor for interaction is that users instantly possess a natural intuition for the effects that their movements have on the system, similar to that described in [14]. Shoogle enables the sensing of the state of a mobile device via the simulation of a physical system which responds to gestural input. By modelling the dynamics of some balls inside a box and the quite intuitive effects of a user's shaking of this box, information can be conveyed, such as the battery life of the device or number of new text messages via the use of auditory impact sounds and haptic rendering.

Using a similar approach, this time with a rotational mechanical system metaphor, we aim to exploit the natural intuition of the user in order to enhance and enrich the process of interaction [7]. The dynamics of this kind of system are similar to that of winding a clock, twisting a door knob or turning a key, all everyday metaphors for which people possess a natural intuition. The feedback generated is completely eyes-free, provided via audio and haptic rendering of the internal states of the simulated dynamic system. Allowing users to perceive the changing physical characteristics of the modelled system can be used to convey much richer information about the current state of the person they are interacting with, via continuous interaction and rich feedback, than a static event-based technique would.

There are a number of conventions that we follow when describing this kind of system. Figure 2(a) defines some of the basic notation. θ is defined as the angular displacement of the rotating disk with respect to some reference and is expressed in radians, ω is defined as the angular velocity of the disk in radians per second, α (i.e. $\dot{\omega}$) is defined as the angular acceleration in radians$/s^2$ and τ is the torque, the rotational analogue of Force, in Newton-meters where $\tau = J\alpha$.

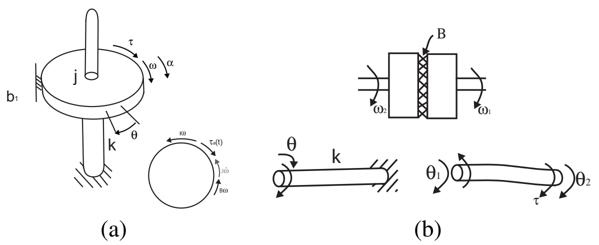

Figure 2: (a) Rotational mechanical system conventions and a free-body diagram representing the forces present on the disk. (b) Rotational stiffness element with $\Delta\theta = \theta_2 - \theta_1$.

The four important characteristics of this kind of system from an interaction design perspective are *torque*, *friction* and *stiffness*, which can be used to feedback device states to the user. *Torque* is important because it provides us with a measure for the amount of force present in the system. *Friction* can significantly affect the feel of a rotational system. Figure 2(b) shows rotational devices characterised by viscous friction, where the torque is defined as $\tau = B\omega$ [3]. *Rotational stiffness* is usually associated with a torsional spring, like that of a clock. An algebraic relationship between the torque τ and the angular displacement θ exists. For a linear torsional spring or flexible shaft $\tau = K\Delta\theta$ where K is the spring constant. Altering the value of K can then have an effect on the overall feel of the system. Higher K values result in a more stiff system. So if all this information is fed back to the user via the audio or haptic channels, it can provide the user with a sense of how the system is reacting to certain events or movements.

Our interaction metaphor is split into two parts. The first part involves the mechanism for scanning the horizon to sense the basic direction of friends. The second part involves the mechanism for actually interacting with another person.

6.1 Bearing Selection - Friction Models

The metaphorical mechanism we use to display the direction of people in the social network involves a single rotational disk attached to a surface with a stiffness shaft. This disk, illustrated in figure 2(a) and demonstrated in figure 1 can be twisted from rest with the torque generated being calculated from a combination of D'Alemberts law and the law of reaction torques, which states that the sum of the forces present on a body must be equal to zero. If we sum the forces on our disk, illustrated in the free-body diagram in figure 2(a), and rearrange for τ, the torque in the system, we get: $\tau_a(t) = J\dot{\omega} + B\omega + K\theta$

Generalising the parameter B to become a non-linear function of θ, $B(\theta)$, we can provide the user with feedback depending on the direction of each person in the network. In this case we have elected to represent the direction of each friend on the compass as an area of increased friction that can be perceived in the torque of the system in a way similar to the twisting of the knob on a safe, for example. Each tick as the knob is twisted represents a user in the social network. Figure 1 illustrates the one-disk system and shows how the torque varies as the device is rotated round 360°. The user senses a spike in the torque for each friend due to the increased friction at that point. The friction is varied depending on the level of precision in the position estimate. If the estimate is not precise (or if the user does not want his location accurately disclosed) a wider and less powerful spike is perceived as shown in figure 1.

6.2 Twisting Disk Metaphor

By extending the system from one disk to two disks connected by a shaft of variable stiffness, it is possible to view the mobile device as being a minimal inertia element, coupled with a rotational system via a rotational stiffness element as illustrated in figure 3. Angle changes in the orientation of the phone represented by disk 2 in figure 3, sensed by accelerometers, act as reference values which drive the rotational system, with the states of this system fed back to the user via vibration or audio. We represent the two-disk system using a state-space. The angular displacement θ_2 on disk 2 as an input to the system in order to observe the effects on θ_1 and ω_1 on disk 1 and is represented as follows:

$$\dot{x} = Ax + Bu \quad (1)$$

$$\begin{bmatrix} \dot{\theta}_1 \\ \dot{\omega}_1 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -\frac{(k_2+k_1)}{J_1} & -\frac{B_1}{J_1} \end{bmatrix} \begin{bmatrix} \theta_1 \\ \omega_1 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{k_2}{J_1} \end{bmatrix} \theta_2 \quad (2)$$

where k_1 and k_2 are the stiffness constants in shaft 1 and shaft 2 respectively, B is the friction element for disk 1 and J_1 is the moment of inertia for disk 1. If we imagine our mobile device to be represented by disk 2 and we exert a roll-axis rotation on the device, this will induce a reaction in disk 1, the exact nature of which depends on the values chosen for k_1, k_2 and B. Now in the case that we have two devices connected with disk 1 representing the mediating agent (as illustrated in figure 3) the value for k_1 in the system for device 1 will come from the value of k_2 in the system for the device represented by disk 3. What this means is that if user 2 changes any parameters in their system, this will have some effect on the response generated in the system for user 1 enabling the potential communication of information. We can automatically link the parameters J, k and B to the user's state, context and history. It is also possible for users to have unique friction and dynamic characteristics meaning that pokes from different people would feel different. One friend might be harsh and abrasive while another is smooth and gentle, for example.

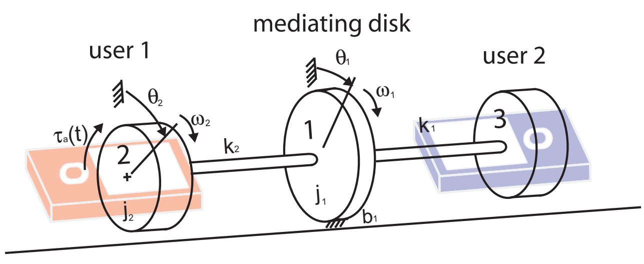

Figure 3: Two users are connected with one disk to a mediating disk which has an oscillatory behaviour which is a function of the parameter settings and the input from each user.

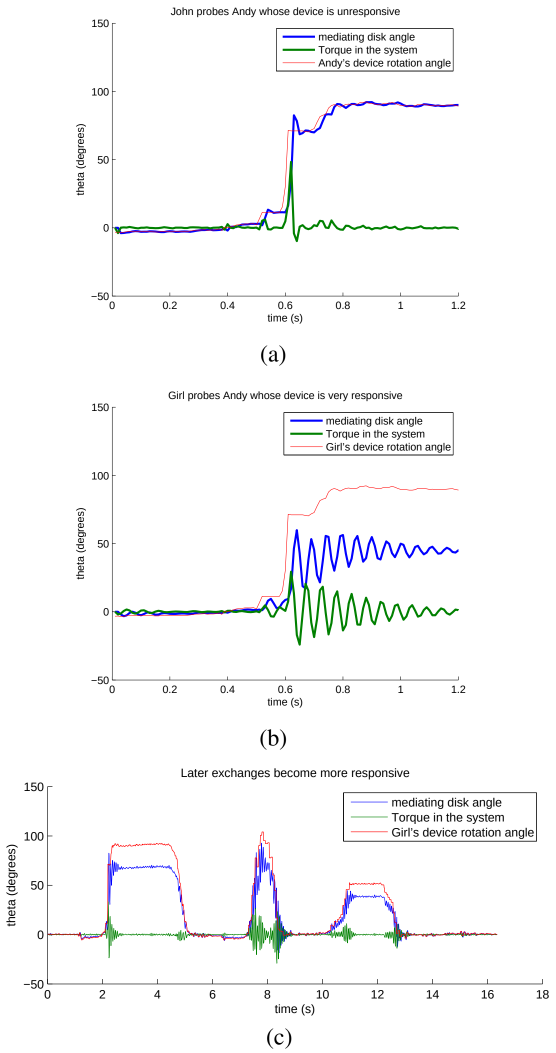

Figure 4: (a) John probes Andy but receives very little response. (b) The girl probes Andy to receive a much stronger response. (c) The response for a number of continuous exchanges.

7. CONCLUSIONS

This paper has introduced and demonstrated the use of dynamic systems for the provision of feedback to the user of a geosocial mobile device. By taking advantage of a user's natural familiarity with the dynamics of a rotational spring mechanical system, as would be found in a door-handle or clock winding mechanism, we have demonstrated that it is possible to produce an eyes-free multimodal display using a solid theoretical foundation as the basis for the interaction design. Coupling such rich continuous-feedback models allow designers to make the user aware, in real-time, of subtle variations in the current state of activities of other members in their social network.

The main benefits of this approach for this kind of application are that the response of the system can be altered with simple parameter changes or combinations and these responses have the potential to convey varying emotions, for example. This also aids privacy, as it allows group specific dialogues to emerge. What makes perfect sense within a group of friends may mean nothing to stranger or less close friend for example. Other benefits of these mechanisms include the dynamic adaptation of the system to varying context changes or changes in the quality of location estimate.

This introductory paper only considers simple non-linear and linear friction and spring models, but it is straightforward to expand the idea to far richer models. In general, there is broad scope for multimodal displays which could, e.g. display the velocity data in audio, and the torque in vibration, and which could have richly nuanced variations in audio and tactile patterns depending on the friction characteristics, which can be a function of automatic interpretation of context or behaviour.

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9. REFERENCES

[1] L. Barkhuus, B. Brown, M. Bell, S. Sherwood, M. Hall, and M. Chalmers. From awareness to repartee: sharing location within social groups. In *Proceedings of ACM SIG CHI Conference*, pages 497–506, 2008.

[2] L. Barkhuus and A. Dey. Location-based services for mobile telephony: a study of users' privacy concerns. In *In INTERACT*, pages 709–712, 2003.

[3] C. Close and D. Frederick. *Modeling and Analysis of Dynamic Systems*. John Wiley and Sons, 2nd edition, 1995.

[4] S. Consolvo, I.E. Smith, T. Matthews, A. LaMarca, J. Tabert, and P. Powledge. Location disclosure to social relations: why, when, & what people want to share. In *CHI '05: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 81–90, New York, NY, USA, 2005. ACM.

[5] Google, Inc. Jaiku. `http://www.jaiku.com`, 2006.

[6] GyPSii, Inc. GyPSii. `http://www.gypsii.com`, 2008.

[7] R. Murray-Smith and S. Strachan. Rotational dynamics for design of bidirectional feedback during manual interaction. In P. Markopoulos, B.D. Ruyter, W. Ijsselsteijn, and D. Rowland, editors, *Fun and Games 2008*, pages 1–10. LNCS 5294, Springer-Verlag Berlin Heidelberg, 2008.

[8] L. Palen and P. Dourish. Unpacking "privacy" for a networked world. In *CHI '03: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 129–136, New York, NY, USA, 2003. ACM.

[9] Pelago, Inc. Whrrl. `http://www.whrrl.com`, 2007.

[10] A. Sellen, R. Eardley, S. Izadi, and R. Harper. The whereabouts clock: early testing of a situated awareness device. In *CHI '06: CHI '06 extended abstracts on Human factors in computing systems*, pages 1307–1312, New York, NY, USA, 2006. ACM.

[11] S. Strachan and R. Murray-Smith. Bearing-based selection in mobile spatial interaction. *Personal and Ubiquitous Computing*, 13/4, April 2009.

[12] S. Strachan, J. Williamson, and R. Murray-Smith. Show me the way to Monte Carlo: density-based trajectory navigation. In *CHI '07: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 1245–1248, 2007.

[13] Twitter, Inc. Twitter. `http://www.twitter.com`, 2006.

[14] J. Williamson, R. Murray-Smith, and S. Hughes. Shoogle: excitatory multimodal interaction on mobile devices. In *CHI '07: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 121–124. ACM, 2007.