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Forest data to insights and experiences using gamification

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1 Introduction

Over the last decade, games have become an increasingly common aspect of contemporary culture, including new uses beyond leisure activities. Games are generally considered to provide cognitive, emotional, social, and motivational benefits (Granic et al. 2014, Ryan et al. 2006). As such, transforming different systems, services, and activities to resemble games has become a common practice in design, commonly known as gamification (Koivisto and Hamari 2019). The aim with gamification is to give rise to similar experiences that games do. There are growing and promising empirical results across various fields on how gamification has been found to engage people in a variety of situations, including education, personal health management, democratic participation, and sustainable consumption, among others (Koivisto and Hamari, 2019). However, there remains opportunity to tap into the potential of these developments in terms of observing and understanding forest ecosystems, planning their use, and to facilitate engagement with nature (Figure 1).

There is currently a proliferation of digital data. New and novel means for making sense and informed use of these data is required. Gamification can bring a human element to dealing with this digital data proliferation and associated collection and processing opportunities, including miniaturization of sensors, development of computational methods, and an increased level of automatization. Nowadays digital data is available from air- and spaceborne sensors observing forests and the Earth's surface on a daily basis (Achard and Hansen 2016). Forest machinery can be used for collecting geolocated data concurrent with specialized sensors observing the operational activity ranging from fuel consumption to harvested tree characteristics. In turn, this data can be linked to the actual work environment by combining orientation and movement data of the cabin and harvester head to the data obtained with Global Navigation Satellite Systems (GNSSs, Hauglin et al. 2017, Noordermeer et al. 2021). Respectively, due to miniaturization of the sensors, consumer-grade devices, such as smartphones can be equipped with laser scanning sensors or applications capable of varied forest observations (e.g. Vastaranta et al. 2015). At the office or when mobile, geographic information systems can be used to simulate and then visualize alternative forest development scenarios and support operational and strategic decision making regarding forest resources.

The concept of gamification provides a vehicle for digital change in the forest sector and has created opportunities to replicate real forest environments to support and inform decision making and for environmental engagement. However, as the digital technology and computational methodologies have developed rapidly, the human-technology interfaces have not kept up with the required technical understanding and needs for investment (Sirgy and Lee 2018). Decision makers and data analysts have difficulties in dealing with large amounts of forest data, the multidimensional aspects of the data to be considered, and subsequently how to address a given problem. In many tasks, such as in forest harvesting, the technology integrated with the task is not used to engage or inform the operators' work on site. Via gamification, real time data for on-board sensors can be combined with static data layers on topography, planned block boundaries, and the like, to provide insights to the skilled operator. Beyond the noted increased integration of gamification to enhance the forest operations work environment, there are also opportunities to use it to enhance forest-related leisure activities. In this communication, we elaborate upon how gamification has been and could support forest related work activities including forest surveys, forest operations, foraging, forest data interpretation and decision making as well as leisure and recreational activities.

Figure 1. In an office setting, gamification approaches can be specifically used for interpreting multidimensional forest data and to present it in a way which makes it possible to engage workers or analysts in a gameful way. These opportunities are envisioned to make gamification an element supporting meaningful, productivity enhancing forest experiences while also creating a more rewarding and interesting work environment.

2 Location-based gaming as a way of supporting forest surveying, operations and recreational activities

Forests are commonly used for geocaching, one of the earliest location-based games that continues to be a popular pastime (O'hara 2008). Location-based gaming has become well known since the global success of Pokémon GO since 2016 giving rise to millions of players visibly transforming parks, streets, and other public spaces. In location-based gaming it is typical that the game mechanics are used to guide movements of the player (Leorke 2018). This core principle can be applied to forest surveys and operations as well as recreational activities. Emerging technologies such as unmanned aerial vehicles (UAVs), wearables (including motion tracking technology, haptic gloves and biometric sensors for example), and extended reality technologies can be used to gamify forest environments by augmenting the physical landscapes with virtual interventions (Buruk et al. 2019). Augmented reality (AR) is the key technology that is used to engage players and it can be implemented using smartphone applications or other virtual reality (VR) devices, such as specific VR headsets.

From a work perspective, the user experience can be made immersive by using wearable technology that is capable of providing AR experiences and collecting relevant forest data simultaneously as even consumer-grade devices, such as smartphones, come with a number of embedded sensors that can be used to characterize forest environments while the worker is implementing required tasks in a gamified environment. For forest professionals, specific wearable technology can be used to make the work experience more engaging, but also to collect data from predefined locations. For example, personal laser scanning has been shown to be an emerging technology for characterizing forest environments while the user is walking around field sites (e.g. Chen et al. 2019). Terrestrial laser scanning (TLS) has been demonstrated to provide unique information at the forest stand level (Boucher et al. 2021), enabling the capture of larger than typical samples that in turn enable locally relevant model development. Extending from TLS to highly mobile backpack mounted units, TLS data can provide otherwise unavailable, non-destructive, measurements of tree taper, towards improving stand volume estimation (Hyyppä et al. 2021). UAV's are increasingly used in forest applications including seedling stand assessments and biodiversity monitoring (Raparelli and Bajocco 2019, Goodbody et al. 2017). Emerging game trends such as drone racing and taking pictures with drones can blur boundaries between typical surveying work and what people choose to do in their leisure time (e.g. Moon et al. 2019). In general, gamification does not change the way the forest observations are collected *per se*, but the way the worker is experiencing the tasks at hand. That is, an aim of gamification in a professional environment is to have the same high quality outcomes, but to allow for a different and more enjoyable path to getting there. In forest operations, screens and monitors of the forest machines can be augmented with gamified elements providing scoring based on site difficulty and tree selection for example. In the training of forest machine operators, simulators with gamified elements have been used successfully for years (Bots and van Daalen 2007). Within the next few years, we expect to see this training element transfer into operations and make daily tasks for forest machine drivers more interesting. As the level of automatization increases, it could even emerge that one human operator is responsible for vehicles operated remotely in a gamified environment. In a digitalized and automatized work environment that requires less human presence on-site, some monitoring tasks may benefit from game elements that keep the operator engaged. In general, information needs of forest management planning or operational activities, such as forest harvesting, provide opportunities to develop and introduce new data collection and interaction opportunities from location-based gaming. Moreover, personal, consumer-grade devices such as active wearables can be deployed to enhance the interactivity of activities such as foraging and hunting.

3 Gamification supporting forest decision making and environmental engagement

It has been shown previously that gamification can improve well-being at work (Koivisto and Hamari 2019, Hassan and Hamari 2020), and it may also support complex decision making. Forest-related decision making is based on various data sources with varying spatial and temporal resolutions combined with multiple stakeholders and decision maker(s) values and expectations. Thus, data remains to be transformed and made more accessible to forest managers, operators, and educators, among other users (Rodrigues et al. 2019). Gamification can be specifically used for interpreting the forest data and to present it in a way which makes it possible to engage the decision maker and the data representing the forest. Creation of virtual realities with advanced visualization techniques will make data easier to understand. For instance, Virtanen et al. (2020) demonstrated how game engines can be extended to include tools for users to interactively visualize and interact with complex data, such as point cloud data. The demonstration and experiences obtained could be extended in the field of forest-related information work as the point clouds are increasingly used as an information source to represent forest environments. To support understanding of the future in addition to the current state of the environment, forest development scenarios can be visualized and built on game mechanics. This kind of concept has been used to support private investors in the field of finance and it has improved understanding of the concepts such as risk and uncertainty (Legaki et al. 2020). These are also the key concepts in forest-related decision making that can benefit from simulations and observations of differing possible outcomes.

It has also been shown that digital connections to forests have provided positive physiological and psychological responses (Yu et al. 2018), whereby positive effects on physiological and psychological health have been obtained from viewing nature-related pictures or movies. To examine the possibilities of the recent VR technology and the influence of forest and urban VR environments on restoration, Yu et al. (2018) conducted a controlled experiment using 30 volunteer participants. Compared to urban VR environments, an increased level of vigor and a decreased level of negative emotions (i.e., confusion, fatigue, anger-hostility, tension, and depression) were observed in simulated forest environments. In this context, digital gamification approaches can be used to engage humans to visit virtual green spaces from nursing homes, between work meetings, or as a part of daily relaxation routines for obtaining health benefits.

4 Discussion

There is a significant potential in combining detailed mapping, forest data, and emerging game and entertainment cultures to develop novel approaches for managing, understanding, and enjoying forests. With regards to location-based game contexts, in forest surveys workers are moving between sites which may enable AR and gamification to be used to guide movements, add motivation for planned tasks, and increase efficiency. There are significant social and societal benefits to more fully utilize the information available regarding our ecosystems in a more comprehensive manner (McCord et al. 2021). Location-based gameful interaction designed around forests is expected to result in innovations in user engagement, data collection, and adaptation of end-user technologies for a forest ecosystem while creating new areas for technologies such as UAVs, wearables and extended reality.

Additional understanding of how gamification can be integrated into the forest sector, what cognitive and social effects they have, and how these effects consequently translate to ecological, economic, and cultural sustainability of forests are under investigation. Gamification is envisioned as a means to improve human well-being by creating meaningful experiences and enhancing motivation. Gamification offers a vehicle for a paradigm change in business practices, transforming the nature of work tasks and promoting stress-reducing practices and enjoyable learning activities. Gamification is foreseen to provide novel services and business initiatives based upon new forest experiences in physical and virtual worlds as well as improved work well-being and recreational use of forests. Incorporating aspects of play and gamification to operational processes, similar to those indicated here regarding forests, are applicable across a range of fields that require complex decision making and use a diversity of data and knowledge factors.

5 Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

6 Author Contributions

Writing - original draft preparation, M.V., M.A.W., J.Ha. and J.Hy.; illustrations, S.J.; writing - review and editing, all authors. All authors have read and agreed to the published version of the manuscript.

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