A proposed framework for the collection of health-related data from Serious Games and Apps

Konrad Peters[1], Fares Kayali[2], Marisa Silbernagl[3], Anita Lawitschka[4], Helmut Hlavacs[5]

[1 corresponding] *University of Vienna, Faculty of Informatics, konrad.peters@univie.ac.at*
[2] *Technical University Vienna, fares@igw.tuwien.ac.at*
[3] *Medical University of Vienna, marisa.silbernagl@meduniwien.ac.at*
[4] *St. Anna Children's Hospital Vienna, anita.lawitschka@stanna.at*
[5] *University of Vienna, Faculty of Informatics, helmut.hlavacs@univie.ac.at*

Abstract

In order to empower the influence and usage of Serious Games for Health (SGFH) in science as well as application, a decision-support-system (DSS) based approach for interpreting game data should be developed. This DSS would allow users (patients, physicians) to interpret medical data, gathered by various serious games, as well as the game-scores of these games. The usage of DSSs implies the requirement for a standardized data model, for both medical data as well as game-proprietary data, such as meta-data or game-scores. This publication presents a framework proposal, which covers the requirements to interpret data of various health- and game-sources and create recommendations to users. Authors identified challenges and experiments to be done: to provide a ubiquitous data model for SGFH, a set of existing games will be analysed and evaluated. Further, a SDK for game developers will be created. This would enable the developers to gain access to the DSS based approach with reasonable effort. Finally, a DSS, consisting of two sub-DSS, should be implemented on top of the previous results.

Keywords: *Serious Games for Health, Standardization, Data Modeling, Decision Support Systems*

1. Introduction

In recent years, a boom of smart devices, as well as services used through them, including social media, entertainment applications and health-related apps, has been observed. Additionally, serious games for promoting healthy habits have received increasing attention.

Health apps are patient-centred apps for smart devices, mostly used to keep track of personal health data, such as fitness/running sessions (*Runtastic*[1], *Endomondo*[2]) or blood sugar levels (*mySugr*[3]) [1]. *Serious Games For Health* (*SGFH*) encompass a subset of serious games; while serious games generally tend to have a different purpose than solely entertainment, SGFH focus

1 https://www.runtastic.com/, accessed 05.05.2017
2 https://www.endomondo.com/,accessed 05.05.2017
3 https://mysugr.com/, accessed 05.05.2017

on a specific health issue, such as, for example obesity, nutrition habits or data-tracking of patients with chronic diseases [2]. These games usually integrate mechanisms to reward activity like data submission, complying with treatment steps or achieving real-life goals and therefore produce game-scores. In order to calculate those scores, some health-related activity, depending on the health issue tackled by the respective serious game, needs to be transferred to the game-logic.

Decision Support Systems (*DSS*) can be used by physicians to facilitate processing large amount of data submitted by different data sources [3]. The medical knowledge for these systems is stored in well-defined knowledge bases, usually limited to a medical subfield. Most clinical DSS are based on one or more clinical guidelines [4].

Addressing the needs of medical professionals in this context can lead to difficulties, as developers of health apps often have no intention or resources to implement a solution, which can be fully integrated into the clinical workflow of physicians. This leads to heaps of unused health data, which could possibly contain important information for the treatment of various health issues, a long as adherence with ethical requirements is ensured. Further, this makes it almost impossible to allow researchers to evaluate and compare the efficacy of apps or games with similar purposes.

1.1 Problem Statement

Health data produced by various *health apps* – and especially *SGFH* – could hardly ever be included into clinical workflows, as the data lacks proper medical definition and does not comply with medical data standards such as *HL7*[4]. For example, in *Spa Play* the user's steps are counted and used within a game to maintain a virtual island [5][6]. The produced data in this case, tracks steps per user per day and can provide valuable information for a general practitioner (*GP*) when treating a patient. Due to the lack of standardized data definitions, the game produces proprietary health data, which can be used by its own evaluation algorithms and services. However, it cannot be forwarded into the existing evaluation systems of a GP and would therefore mean additional effort for the GP to include this data into his treatment considerations. An integration into existing data evaluation software, mostly implemented through electronic health records (*EHRs*), would be the most convenient way for a GP to include serious game data into a patient's treatment plan.

Further, the growing number of SGFH and their proprietary data would soon overwhelm any GP willing to integrate the health information, gathered by the medical components of the serious game, especially when a patient would be using multiple serious games or apps. In order to not be too time-consuming for the GP, health-related data has to be prepared and evaluated according the GP’s needs. The use of DSS would be a promising approach to join and present data for the patient as well as a GP [3]. However, DSS require formal and standardized data input, which contradicts the data issues mentioned above - each SGFH produces its own set of proprietary data, be it the actual activity measured by the game or the actual in-game scores. In order to create an almost-generic DSS, which can be driven by data of various serious health game developers, a comprehensive data-mapping tool must be available for the developers, even after authoring the respective game.[5]

4 http://www.hl7.org/, accessed 05.05.2017

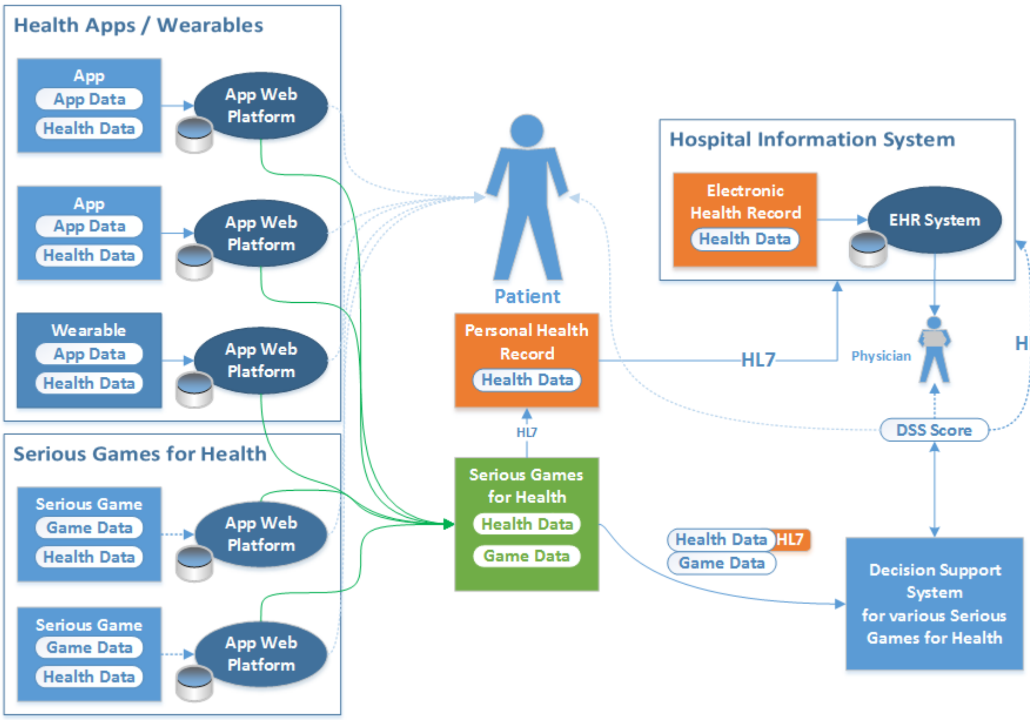

Figure 1: the status quo of various health data and app data sources

Figure 1 shows the current status of health apps, wearables and SGFH in relation to patients, their personal health records and the integration into the workflow of physicians. Most of the available apps have a proprietary web platform, where the patient/user can log in and review the data history. In some cases the apps or wearables offer integration into existing personal health records (PHRs) through the use of standards (e.g., if part of the IHE program[6]) and some SGFH are also able to integrate their gathered health data into PHRs (depicted by dotted arrows). However, these are usually tailored proprietary solutions, which implies additional development and maintenance costs.

By enabling SGFH to produce semantically rich and standardized health data, which can be integrated into existing hospital information systems (HIS) or EHRs, patients as well as their caretakers would benefit considerably. Furthermore, if the health-data as well as game scores would be evaluated by a DSS-driven solution, physicians and other professionals would be provided with meaningful information regarding a patient's health status. The challenges of the implementation of such a system include to implement a ubiquitous DSS, which is able to interpret data from various different serious game developers. This includes the game-scores as well as the health data. The integration of the results of such a DSS into existing HIS/EHR solutions is realized by the implementation of standardized interfaces and libraries (such as *HL7 FHIR*[7]), which are well documented but imply a much higher implementation effort than proprietary solutions.

[6] http://www.ihe.net/, accessed 04.06.2016
[7] https://www.hl7.org/fhir/, accessed 06.02.2017

2. Related Work

2.1 Literature & State of the Art

Serious games with health content were researched in the work of *Primack et. al* [7], where various positive aspects like education in health matters, motivation during difficult health episodes, enhancing treatment compliance as well as therapy support through physical exercises were covered. The use of (voluntary) app certification schemes for SGFH (e.g., HACP[8]) are found to be useful [1].

The architecture of a possibly ubiquitous clinical DSS was conceptualized and discussed by Peleg and colleagues [8]. The authors state, that in order to make SGFH more efficient, the context of patients must be included when interpreting their health status, also when using health apps or SGFH.

The project INTERACCT and its underlying design considerations are described in more detail in another paper provided by Kayali and other authors of this work [9]. In INTERACCT, a mobile app for young leukemia patients after receiving stem cell transplantation was developed. The app acts as a diary for the patients, submitting formal and standardized health data to the aftercare-center of the collaborating hospital from the patient's home. Entered data is embedded into a serious game, the patients will progress faster and more successfully through the game, when they submit their data regularly. As a subproject of INTERACCT, a physiotherapy-game using a Microsoft Kinect2 was implemented [9]. A set of physiotherapy exercises can be done independently by the patient in front of a Kinect2, the generated data is stored and evaluated in the overall evaluation system of INTERACCT.

In 2014, Zhao et al. investigated the technical capability of a Microsoft Kinect Sensor, evaluating 5 different rehabilitation exercises using a rule-based approach [10]. A system for pediatric patients doing physiotherapy exercises with NAO robots[9] was implemented by Gonzales and Pulido [11]. However, both approaches lack proper standardized data definitions or evaluation capabilities.

For physiotherapy, an example of a commercial products in use is. *Jintronix*[10], which uses Microsoft Kinect motion tracking for physiotherapy treatment of stroke patients. In supervised sessions, patients are asked to complete comprehensible minigames which train their motoric skills. Based on the patient's health status the difficulty adapts. Scores are tracked and accessible for clinicians at any time through an online-portal, however they are not forwarded to a HIS [13] [14].

In *Online-Gym* virtual 3D gymnasiums were implemented, to enable patients with restricted mobility to participate in virtual physiotherapy sessions. However, no details regarding data context of the standards was mentioned [14].

Step counter implementations such as *Move My Day*[11] are currently developed and evaluated on different levels, such as behavioral change models behind recommendation adherence [15]. Other examples for serious games to increase mobility of patients are presented in [6] and [16].

In gait rehabilitation, a serious game was implemented using a reactive LED floor to give patients live feedback and a playful experience [17]. The generated data is stored in a proprietary form and can therefore not be used for comparison with not-gamified approaches. The same main author designed a serious game for young cerebral palsy patients – stating that tangible interactive games prove enhanced rehabilitation results [18].

8 https://www.happtique.com/, accessed 06.02.2017
9 https://www.ald.softbankrobotics.com/en/cool-robots/nao, accessed 10.02.2017
10 http://www.jintronix.com/, accessed 06.02.2017
11 https://play.google.com/store/apps/details?id=interactivesystems.movemyday, accessed 10.02.2015

3. INTERACCT

The following chapter will describe our personal experiences in the development of a SGFH for the usage in the medical field.. In a multidisciplinary research project called “Interacct”, a SGFH for young oncological patients was implemented. The lessons learned were one of the core motivations for this contribution.

3.1 Project Description

Allogeneic hematopoietic stem cell transplantation (HSCT) has been a path-breaking discovery in the field of oncology, proven to be a cure for many diseases like leukemia or red-cell disorders. Technical and supportive care have resulted in survival rates of more than 70% within the first two years after HSCT. However, long-term survivors carry a high burden of morbidity, including infections, treatment related organ toxicities, musculoskeletal disorders, endocrinopathies and immunological complications like graft versus host disease (GVHD) [19]. They usually affect multiple organs and tissues, and exhibit a variable clinical course [20]. In any case, early recognition is crucial to initiate timely and sufficient treatment [21].

Currently, no adequate technological monitoring solutions are available, especially for young HSCT patients. The current procedure is the use of a paper diary, where patients track their health data and present it to their aftercare physician once they visit the hospital, either during a scheduled visit or because the patient's condition has worsened. Prior examples of electronic diary solutions have proven to provide better integration into everyday routines [22]. For the successful design of self-monitoring technology, Grönvall and Verdezoto [23] recommend a holistic perspective considering seven non-functional aspects (people, resources, places, routines, knowledge, control and motivation). Furthermore it was shown that electronic health monitoring technology potentially eases the interaction between young patients and their parents [24]. In 2015, Grönvall and colleagues [25] proposed that health care technology focus on participative and collaborative approaches to doctor-patient communication. The Project *INTERACCT* also uses game-based concepts, which have proven to be effective in increasing compliance [26] and motivation [27].

In the project INTERACCT one of the partners is an outpatient clinic for young HSCT-patients. The primary healthcare needs identified in dialogue with a medical expert are issues of patient motivation and compliance in a long-term setting (2 years and longer) and the need for an immediate solution for remote doctor-patient communication. Therefore, facilitating the communication process of the patient informing the physician about actual health data is necessary. Building on the potential of games and self-monitoring technology, a game-based concept of a reporting tool was created in the project INTERACCT. In the project, a serious game for health, targeted at children after HSCT treatment, is designed and developed in an interdisciplinary setting of partners with backgrounds in computer science, arts, game design, psychology and medicine.

The goal of INTERACCT was to develop a game-world which appeals to a young target audience aged 6 to 18 years. Due to the nature of the primary disease, the target audience is highly heterogeneous. It includes children with differing ethnic background and from different social classes. Children in the target audience are further separated by changes in health, well-being, psycho-motor and psycho-social developmental status due to the HSCT treatment. The INTERACCT game was designed to provide high adaptability to accommodate changing circumstances in health, age and social context of patients.

3.2 Project Components

The project INTERACCT consists of some defined components, which collaborate but require differential approaches for design and implementation. This section briefly describes the different components to help depicting the functionality of the whole project.

Game World: the game world of INTERACCT is a 2.5 dimensional adventure game, where players work their way through procedurally generated levels with fantasy-avatars. These levels are designed in one of four graphical settings (earth, air, fire, water) and are packed with hidden treasures (in-game consumable items), but also hostile avatars, which attack the player’s avatar if it comes too close. A simple combat mechanism should encourage the player to his avatar, and eventually find additional avatars. Figure 2 shows a user's avatar (black cat on the left) in mid-fight with a hostile avatar (penguin).

Figure 2: game world component of INTERACCT

Data Entry: prior to entering the actual *game world* with the avatar described above, the user is asked to enter some medical parameters within the game. The amount of these parameters is set by the treating medical expert and is in-game rewarded with points to level up the avatars. Around 45 parameters are defined by the medical experts, where possible using LOINC codes for description and scale (range of possible values, where defined by standard). The amount of mandatory parameters can be defined for each patient by the medical expert, so different health conditions can be covered by explicitly demanding information regarding certain health parameters (like e.g., the amount of fluid intake per day, appetite or pain in certain body areas, and others). However, the user can always fill as many health parameters as desired. One main focus was to implement data entry as non-verbal as possible, using self-explaining icons and drawings. An example for the data entry overview as well as the data entry mask for body temperature is shown in Figure 3.

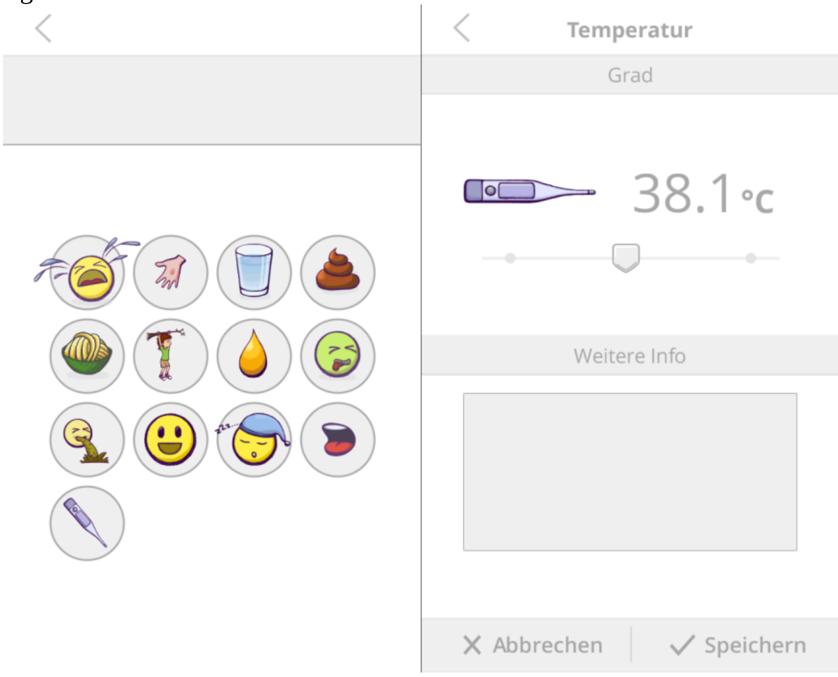

Figure 3: data entry in INTERACCT, on the left side the overview of (an excerpt of) possible parameters, on the right side data entry for body temperature

Physiotherapy: as an extension to the mobile game client (which includes the *game world* and the *data entry* introduced above), users can play a specifically designed physiotherapy game on a PC with the use of a Microsoft Kinect (refer to [28] for details). The exercises implemented were instructed by physiotherapists of the collaborating hospital. Scores created by the physiotherapy game are transferred to the same database as for the mobile client and are therefore complementary for evaluation by the medical experts. A correlation between physiotherapy scores and certain health parameters could become evident very quickly. A screenshot of the first implemented prototype can be seen in Figure 4, where the blue creature on the right side is giving instructions of which physiotherapy exercise needs to be executed by the user.

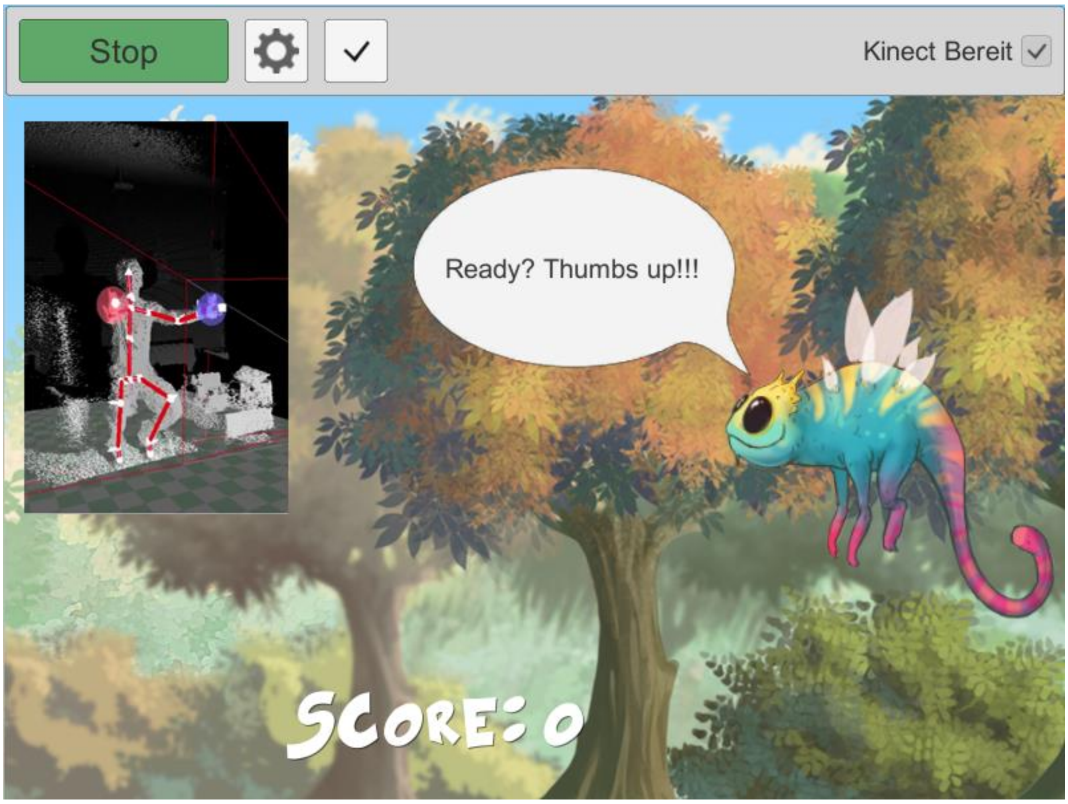

Figure 4: basic prototype for a physiotherapy game using a Microsoft Kinect

Medical Expert UI: in order to evaluate data produced by the preceding components (*game world*, *data entry*, *physiotherapy*), a medical expert UI was implemented. The UI is an asp.NET application, thus running in any state of the art web browser with no specific plugins or frameworks required. The UI enables the medical experts to assign treatment profiles to patients, which result in different sets of data *entry* parameters on the mobile client for every participant individually. Further, the UI gives an overview of data submitted by all patients, divided into 3 risk groups (which patients are assigned to manually by the medical experts). Data can be explored for each patient individually, either by creating charts directly in the web browser or by browsing/exporting data for statistical use.

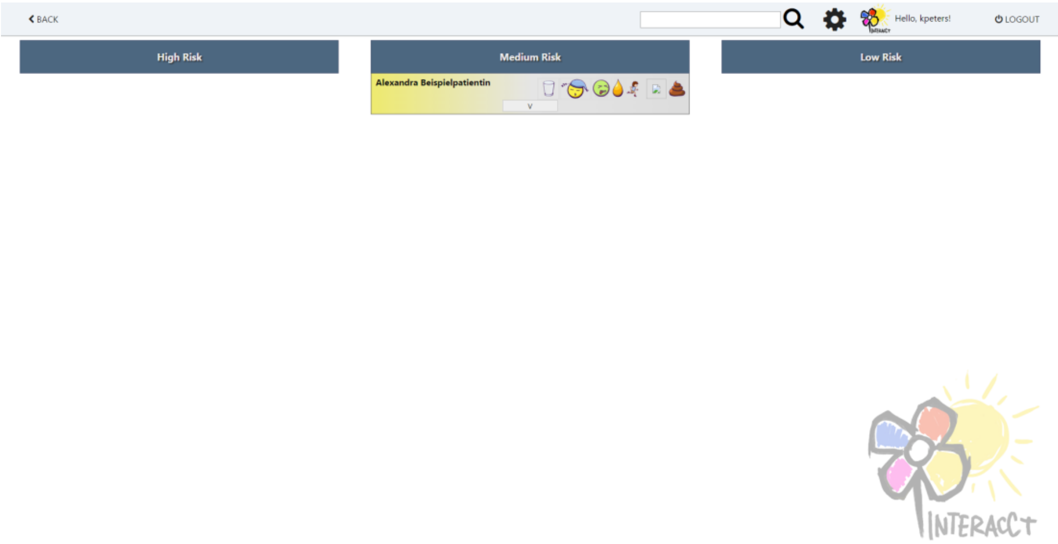

Figure 5: medical expert UI of INTERACCT, patient overview (only one patient visible in the middle column, highlighted in yellow).

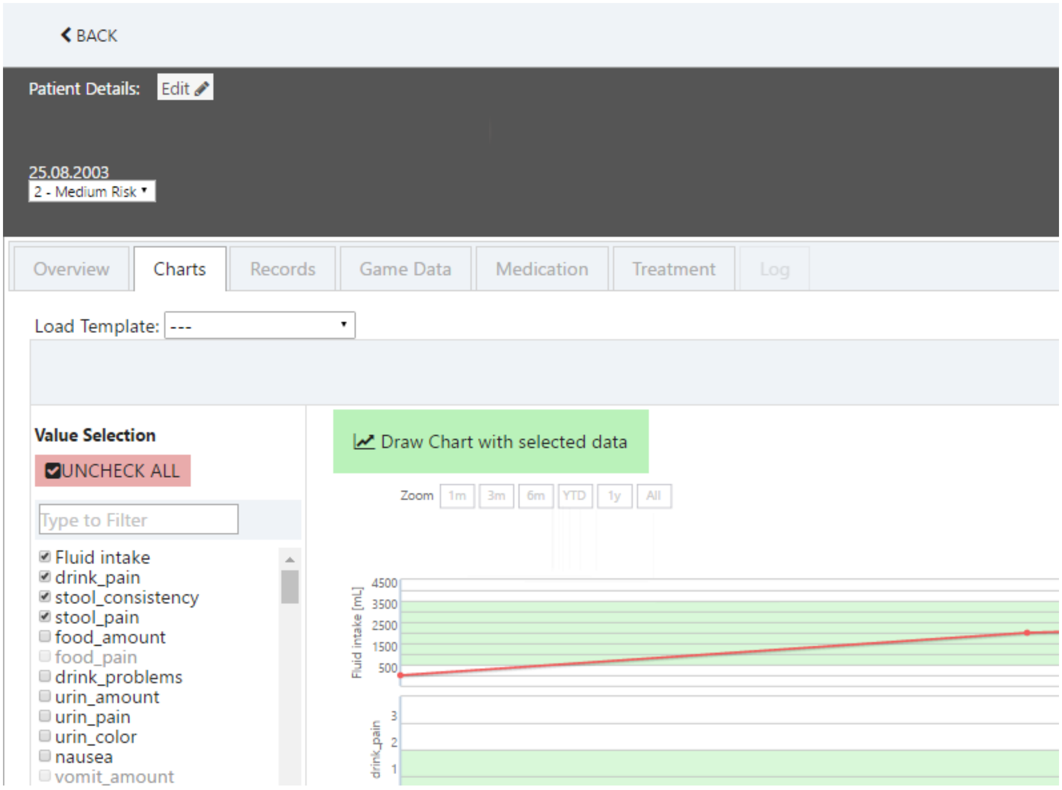

Figure 6: medical expert UI of INTERACCT, part of patient detail view

Game Content Generation: to meet the expectations (regarding game design and content) of the target-group, content generation of INTERACCT was highly prioritized. Content for the *game world* was designed in workshops with children of the actual age group (10-14 years) and processed by professional artists. The output of these workshops were mainly drawings for avatars (which are used to explore the in-game levels) and are discussed in detail by Kayali and colleagues [29]. The levels of the *game world* are using procedural content generation, so theoretically the users could explore an almost endless number of new levels. Further, a storytelling competition, called *Tröstgeschichten*[12], was held over the timespan of one year, where children between 6-14 years were asked to submit short stories through a website. The topic of those short stories was "*how would you comfort a friend that got sick?"* and submissions were reviewed by teachers and volunteers. At the end of the storytelling competition, a jury of renowned Austrian writers and poets picked the best 40 stories (out of over 200 submissions), which were eventually printed into a book. The accepted stories (around 120 out of 200 submissions) are fed into the mobile client randomly once per day, so users get to read new stories every day.

3.3 INTERACCT – Lessons learned

In the first playtests, held at the University of Vienna, 9 healthy children of the target age group were invited to test the *Game World*, Data *Entry* and *Physiotherapy* components of the project. The evaluated results are mostly positive: when using the app, participants *felt good* and *felt satisfied.* Details of methods and evaluations are stated in another publication by the authors [30].

One of the major insights during the development of INTERACCT was that definition, gathering and evaluation of data parameters in the setting of SGFH is highly challenging. While some health parameters (e.g., fluid intake per day, pain in a specific region, etc.) are defined by standards like *LOINC*, others are highly specific and subjective (e.g., psychological parameters like mood, fear; but also physical activity, such as walking, playing or climbing stairs). This challenge also holds true for actual in-game data, such as *level completion*, *session duration* or *continuous game progress.* Gathering data by *exergames* combines the difficulty of both mentioned parameter types (health data and game data).

These challenges propagate from the data-gathering to the evaluation. Once the parameters are defined, they need to be brought into context and evaluated. Early on, we proposed that game-scores could be an indicator for the health-status of players [31]. However, without a well-defined framework for the parameter design of SGFH, evaluation will always be mapped to proprietary solutions and therefore hardly comparable. Altogether, these obstacles were a main motivation for this contribution.

4. Solution Approach

4.1 Overview

This chapter depicts the proposed solution approach for the presented problem. The first sub-section of this chapter gives a short solution outline. To clarify data connectivity, a short section should give insights on how various data interfaces are designed. Implementing a DSS based solution requires increased time and effort spent on data modeling, especially for a thriving but young field of science like SGFH. Therefore, the following sub-section of the solution approach is *data modeling*, where an outline of how a correct data model can be developed is described. Subsequent, a *SDK* for game developers is outlined. This *SDK* should facilitate the integration of

[12] https://www.interacct.at/troestgeschichten/, accessed 30.01.2017

the full solution into newly developed SGFH. The third subchapter, *DSS & Knowledge Engineering* sketches the DSS component of the solution approach. It describes the overall idea of where artificial intelligence in form of DSS could be applied. Concluding, the chapter *Integrating existing SGFH* describes considerations of how already developed SGFH could be included in the solution approach.

4.2 Solution Outline

The proposed solution is based on a unified data interface for various SGFH. Since every suitable SGFH comes with a server as a backend and data storage, the data interface will rather be implemented on the server side than on the app/client side. The app server will forward the data to a web service, which acts both as data repository as well as the outgoing data interface for the DSS and the medical data records (personal health records, electronic health records). The DSS will calculate a structured health score, based on health data, game scores and game metadata. This health score could be e.g. on a scale of 0-100 and offer more details, if a user wants to investigate how the score was composed. The user will be able to opt in for each SGFH individually, after being instructed that data from more SGFH will produce more accurate results by the DSS. Further, the user will be able to forward the DSS score to the treating physician, who is able to inject the produced data (health score as well as actual medical data produced by the SGFH) into the clinical records of the patient.

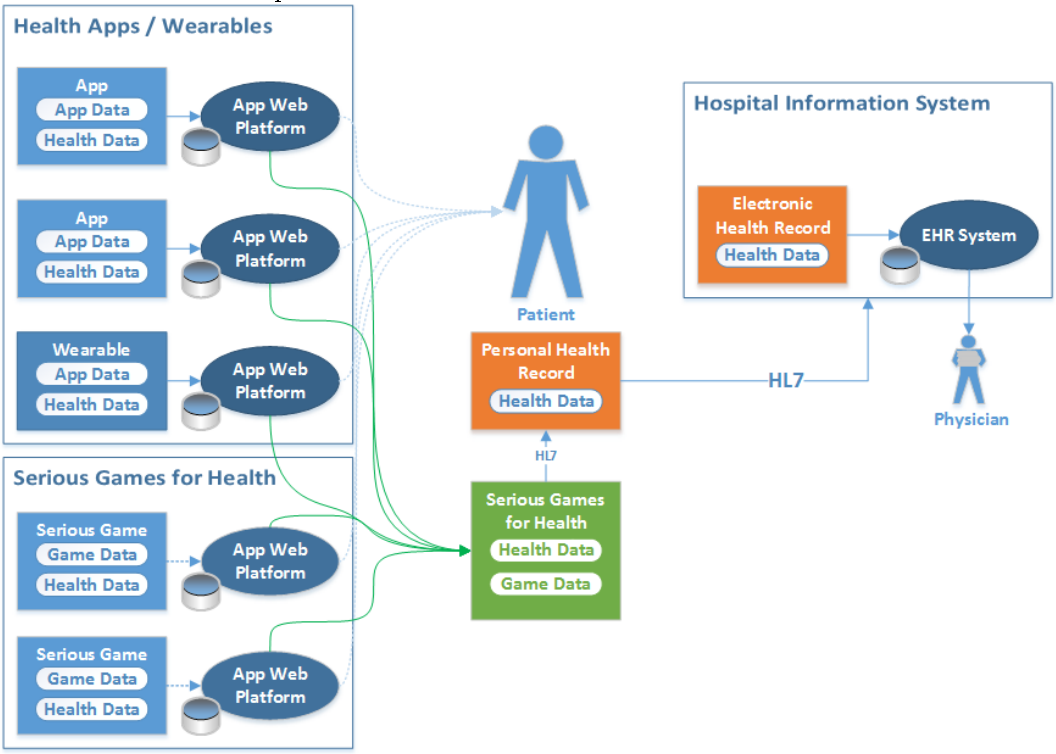

Figure 7: solution outline for a system interpreting serious games for health data using decision support system support

The system described above is depicted in Figure 7. The components on the left side of the figure are showing distinct health apps and SGFH. Each of those apps/games usually have a proprietary web platform in which they store the patient's data. Using those web platforms, the data will be forwarded in a structured manner to be stored in the central solution's web service (which holds the data entities depicted as the green square *Serious Games for Health* in the middle of the figure). This data will then be forwarded to the DSS (on the lower right part of the figure), which serves its produced health scores back to the patient, to the physician and even directly into an EHR system of a hospital. Also, structured health data is stored in a *PHR*, which is accessed by the patient directly or also through a hospital information system.

Eventually, game developers do not need to bother with implementing medical data interfaces, but can focus on their field of expertise. Physicians gain a comprehensible and clear source of combined data sources and can therefore optimize their treatment accordingly. Patients are encouraged to improve their health through appealing, state-of-the-art apps and SGFH and can provide their physicians with a reliable data source.

4.3 Data Connectivtiy

Data exchange and connectivity should, where possible, be standardized. API endpoints involving HL7 (for medical data) are using HL7 FHIR endpoints[13], which can either be (among others) RESTful interfaces or LLP TCP[14] endpoints. The other API endpoints (left-hand in Figure 7: *Health Apps / Wearables and Serious Games for Health* connecting to *Patient / SGFH*) should be defined in a similar fashion, yet always establish connection through secure layers (*SSL*). Further details on data exchange would need to be discussed with experts while implementing first test cases.

As mentioned earlier, content will be transferred via secure transport layers only. The content will most probably be transferred as JSON objects or XML, since both formats are supported by HL7[15]. While XML tends to be better human readable, JSON objects are more lightweight. The proposed framework could be able to interpret both formats, since conversion is a rather trivial task.

4.4 Data Modeling

The proposed data model should be capable of mapping the different types of game-related data (e.g., achievements, usage statistics and patterns, scores, in-game events, etc.) as well as health data (e.g., amount of steps taken in a period of time, burnt calories, repetition of defined physiotherapy exercises, etc.). Further information, such as meta-data about the source (app/game, version, operating system) as well as about the user (gender, age, etc.) should also be included. For processing data to standardized medical data interfaces, a thorough analysis of existing models, such as the HL7 v3 RIM[16] has been conducted. A first draft for a data model can be seen in Figure 8.

[13] http://www.hl7.org/fhir/endpoint.html, accessed 05.05.2017
[14] http://www.hl7.org/fhir/codesystem-endpoint-connection-type.html#endpoint-connection-type-hl7v2-mllp, accessed 05.05. 2017
[15] http://www.hl7.org/fhir/formats.html, accessed 05.05.2017
[16] http://www.hl7.org/implement/standards/rim.cfm/, accessed 06.02.2017

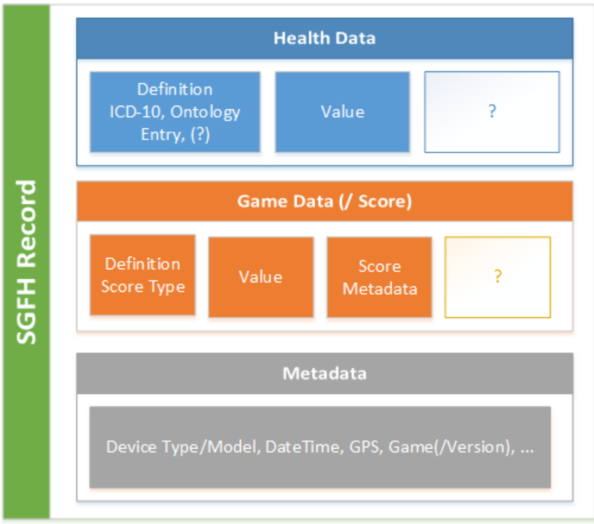

Figure 8: data model approach for a SGFH record

4.5 SDK

A SDK for game developers should be created with the previously created and tested data model. The scope of the SDK is to facilitate the implementation of health data exchange processes for game developers, when creating a new SGFH or health app. Simplified, the usage of the SDK should empower a SGFH or health app to create semantically meaningful medical data and the possibility to exchange this data with standardized interfaces. The feasibility of being able to integrate the functionality of the SDK into existing apps must be investigated. However, an alternative approach for existing apps is planned (see subsection *Integrating existing SGFH* in the current chapter).

4.6 DSS & Knowledge Engineering

The overview of the DSS component of the proposed framework is shown in Figure 9. Basically the DSS should be divided into two sub-DSSs: a clinical DSS and a serious game DSS. Each sub-DSS has its own knowledge base (*KB*) and an inference engine, based on their according KBs. Once each sub-DSS finished processing data, both recommendations are consequently reprocessed by a combined inference engine, based on the KBs of both sub-DSS. The output recommendation consists of a health-recommendation (HL7 standardized) as well as a serious game recommendation. While the recommendation can be seen as an overall output, its components can also be interpreted independently.

The clinical DSS component of the proposed framework should be designed and implemented based on Arden Syntax. Arden Syntax is a standard for representing clinical and scientific knowledge and is maintained by the HL7 organization [32]. Knowledge (*medical logic modules*, (MLMs)) can be written in plain-text and is human-readable, which brings advantages in developing a knowledge base and a rule-set. Further, fuzzy logic is possible when using Fuzzy Arden Syntax. In general, DSS require formal data input to process, which confirms the claim for standardized data output of SGFH.

The serious game DSS is less standardized than the clinical DSS. In order to define a suitable knowledge base and inference engine, experiments on existing SGFH are planned. These experiments involve examining the data structure, scoring mechanisms and metadata and should be the base for first drafts of a suitable SGDSS.

Volume 4, Issue 2, June 2017
http://dx.doi.org/10.17083/ijsg.v4i2.162

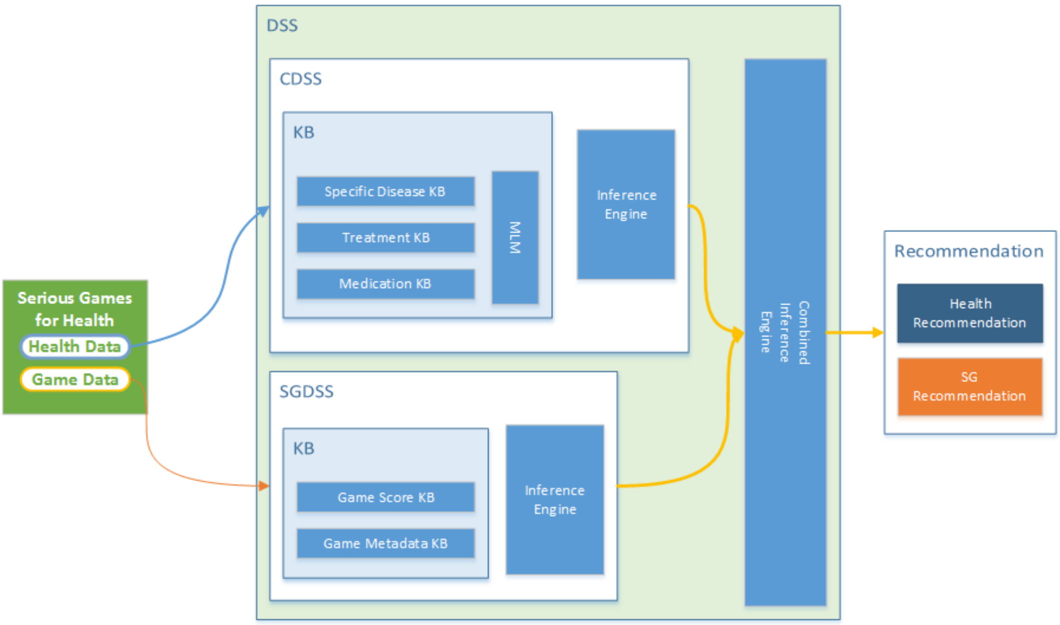

Figure 9: DSS concept for the proposed framework. Health data is processed by a clinical decision support system (CDSS), game data by a serious game decision support system (SGDSS). Data flow from left to right, from data input to a recommendation.

4.7 Integrating existing SGFH

In order to make various existing data sources use the proposed DSS, a mapping and registration process should be implemented. In this registration process, the developer of a SGFH will define which in-game score mechanics are used as well as which health data is tracked. Once registered, the SGFH will be provided with a data-interface, which will receive anonymized live data and in return provide the SGFH user with a calculated health score based on the input data. This should substitute the usage of the previously mentioned SDK and make it even easier for existing applications to make use of the proposed system.

This process should first be tested with SGFH developed by the University of Vienna / Entertainment Computing, such as INTERACCT, the INTERACCT physiotherapy component. Once validated in-house, further co-operations with interested researches and institutions (such as the University of Applied Sciences, Vienna) should be fostered and tested. In a final step, the registration service should be available for international researchers to produce various test cases.

5. Outlook, Conclusion

The presented topics and solution approaches implicate a couple of differences. First, it is challenging to try to design a ubiquitous data model for SGFH, mainly because of the vast variety of possible games, mechanics and medical topics which are covered. Even if the data model is able to depict most of upcoming games, without proper engagement, game developers won't know about the possibility to use a specific, predesigned data model. Further, trying to represent game data in medical information systems is a novel approach. This is mainly due to the obstacle of trying to define data originating from SGFH in nomenclatures made for medical data.

However, the overall approach seems promising: improving the health of people through the usage of SGFH could drastically change the perception of SGFH in both medical-scientific community and the public. Not only would a healthy lifestyle be propagated with innovative and appealing methods (in form of SGFH), the produced data could also give insights on public health matters.

For the near future, the implementation and validation of the proposed data model will be the first step to undermine the solution approach. In the meantime, requirement analyses for medical data interfaces and DSS will be conducted with experts of the relevant scientific fields. In prototype applications, the concept should be tested and critically evaluated.

The presented work proposes a framework concept for a system, able to interpret SGFH data as well as health data and give recommendations to physicians and/or patients. The integration of various sources of SGFH data and health data is identified as one of the major challenges. As an example of a SGFH including game- and health data, the project INTERACCT is given. INTERACCT was implemented and evaluated in detail in other publications, the results are resumed in this publication. To achieve successful data integration from various health- and SG-data sources, the authors propose a ubiquitous data model and present a first possible draft of this data model. This draft will be evaluated in the near future, mapping it to existing SGFH. Further, the DSS component of the system is outlined. The basic concept includes two sub-DSSs, a clinical DSS and a serious game DSS. Once the challenges regarding data formats are solved, the actual design and implementation of the proposed DSS will be done.

References

[1] Boulos, Maged N.Kamel, Brewer, Ann C., Karimkhani, Chante, Buller, David B., and Dellavalle, Robert P., "Mobile medical and health apps: state of the art, concerns, regulatory control and certification.," *Online J. Public Health Inform.*, vol. 5, no. 3, p. 229, 2014.

[2] Miller, Aaron S., Cafazzo, Joseph a, and Seto, Emily, "A game plan: Gamification design principles in mHealth applications for chronic disease management.," *Health Informatics J.*, pp. 1–10, 2014.

[3] Stead, William, Searle, John, Fessler, Henry, Smith, Jack, and Shortliffe, Edward, "Biomedical Informatics: Changing What Physicians Need to Know and How They Learn," *Acad. Med.*, vol. 86, no. 4, pp. 429–434, 2011. https://doi.org/10.1097/ACM.0b013e3181f41e8c

[4] Seitinger, A. *et al.*, "An arden-syntax-based clinical decision support framework for medical guidelines - Lyme borreliosis as an example," *Stud. Health Technol. Inform.*, vol. 1981251321, no. http://www.scopus.com/inward/record.url?eid=2-s2.0-84903732814&partnerID=40&md5=177b3c7f591bf6d352e6472c27101160, pp. 125–132, 2014.

[5] Gong, Diankun et al., "Enhanced functional connectivity and increased gray matter volume of insula related to action video game playing," Sci. Rep., vol. 5, p. 9763, Apr. 2015. https://doi.org/10.1038/srep09763

[6] Durga, Shree, El-nasr, Magy Seif, Shiyko, Mariya, Sceppa, Carmen, Naab, Pamela, and Andres, Lisa, "Leveraging Play in Health-Based Games to Promote Sustained Behavior Change in Healthy Eating and Exercise," in DiGRA 2011, 2011, pp. 1–17.

[7] Primack, Brian A. et al., "Role of Video Games in Improving Health-Related Outcomes:A Systematic Review: A Systematic Review," Am. J. Prev. Med., vol. 42, no. 6, pp. 630–638, 2012. https://doi.org/10.1016/j.amepre.2012.02.023

[8] Peleg, Mor, Broens, Tom, González-Ferrer, Arturo, and Shalom, Erez, "Architecture for a Ubiquitous Context-aware Clinical Guidance System for Patients and Care Providers," Jt. Int. Work. KR4HC/ProHealth 2013, vol. 13, pp. 161–167, 2013.

[9] Peters, Konrad et al., "INTERACCT: Remote data entry system with game-elements for young leukaemia patients," in 2015 17th International Conference on E-Health Networking, Application and Services, HealthCom 2015, 2016, pp. 369–374.

[10] Zhao, Wenbing, Espy, Deborah D., Reinthal, M.Ann, and Feng, Hai, "A feasibility study of using a single Kinect sensor for rehabilitation exercises monitoring: A rule based approach," in 2014 IEEE Symposium on Computational Intelligence in Healthcare and e-health (CICARE), 2014, pp. 1–8. https://doi.org/10.1109/cicare.2014.7007827

[11] González, José Carlos, Pulido, José Carlos, Fernández, Fernando, and Suárez-Mejías, Cristina, "Planning, execution and monitoring of physical rehabilitation therapies with a robotic architecture.," in Studies in health technology and informatics, 2015, vol. 210, pp. 339–43.

[12] Norouzi-Gheidari, Nahid, Levin, Mindy F., Fung, Joyce, and Archambault, Philippe, "Interactive virtual reality game-based rehabilitation for stroke patients," in 2013 International Conference on Virtual Rehabilitation (ICVR), 2013, no. August, pp. 220–221. https://doi.org/10.1109/ICVR.2013.6662126

[13] Tao, G., Archambault, P. S., and Levin, M. F., "Evaluation of Kinect skeletal tracking in a virtual reality rehabilitation system for upper limb hemiparesis," in 2013 International Conference on Virtual Rehabilitation, ICVR 2013, 2013, pp. 164–165. https://doi.org/10.1109/ICVR.2013.6662084

[14] Cassola, Fernando, Morgado, Leonel, de Carvalho, Fausto, Paredes, Hugo, and Fonseca, Benjamim, "Online-Gym: A 3D Virtual Gymnasium Using Kinect Interaction," Procedia Technol., vol. 13, no. 0, pp. 130–138, 2014. https://doi.org/10.1016/j.protcy.2014.02.017

[15] Hermanny, Katja, Ziegler, Jürgen, and Dogangün, Aysegül, "Supporting Users ind Setting Effective Goals," in Persuasive 2016, Lncs 9638, Springer, 2016, pp. 15–26.

[16] Fassbender, Eric and Jones, Christian Martyn, Virtual, Augmented Reality and Serious Games for Healthcare 1, 1st ed., vol. 68. Springer-Verlag Berlin Heidelberg, 2014.

[17] Van Delden, Robby et al., "Personalization of gait rehabilitation games on a pressure sensitive interactive LED floor," in CEUR Workshop Proceedings, 2016, vol. 1582, pp. 60–73.

[18] Van Delden, Robby, Aarts, Pauline, and Van Dijk, Betsy, "Design of tangible games for children undergoing occupational and physical therapy," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), vol. 7522 LNCS, Springer, 2012, pp. 221–234. https://doi.org/10.1007/978-3-642-33542-6_19

[19] Baker, K.Scott et al., "NCI, NHLBI first international consensus conference on late effects after pediatric hematopoietic cell transplantation: state of the science, future directions.," Biol. Blood Marrow Transplant., vol. 17, no. 10, pp. 1424–7, 2011. https://doi.org/10.1016/j.bbmt.2011.06.007

[20] Tamari, Roni and Castro-Malaspina, Hugo, "Allogeneic haematopoietic stem cell transplantation for primary myelofibrosis and myelofibrosis evolved from other myeloproliferative neoplasms.," Curr. Opin. Hematol., vol. 22, no. 2, pp. 184–90, 2015. https://doi.org/10.1097/MOH.0000000000000121

[21] Pranab Sharma Acharya, Shiksha Kedia, "Infectious Complications of Hematopoietic Stem Cell Transplantation," J. Stem Cell Res. Ther., vol. s3, no. 1, p. 2, 2013.

[22] Aarhus, Rikke, Ballegaard, Stinne a, and Hansen, Thomas R., "The eDiary: Bridging home and hospital through healthcare technology," in Ecscw 2009, no. September, Springer, 2009, pp. 63–83.

[23] Grönvall, Erik and Verdezoto, Nervo, "Beyond Self-Monitoring : Understanding Non-functional Aspects of Home-based Healthcare Technology," in Proceedings of the 2013 *ACM international joint conference on Pervasive and ubiquitous computing*, 2013, pp. 587–596. https://doi.org/10.1145/2493432.2493495

[24] Toscos, Tammy, Connelly, Kay, and Rogers, Yvonne, "Best Intentions: Health Monitoring Technology and Children," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 2012, pp. 1431–1440. https://doi.org/10.1145/2207676.2208603

[25] Grönvall, Erik and Sokoler, Tomas, "Concordance : A Critical Participatory Alternative in Healthcare IT," Aarhus Ser. Hum. Centered Comput., vol. 1, no. 1, pp. 21–24, 2015. https://doi.org/10.7146/aahcc.v1i1.21315

[26] Kato, P. M., Cole, S. W., Bradlyn, A. S., and Pollock, B. H., "A video game improves behavioral outcomes in adolescents and young adults with cancer: A randomized trial," Pediatrics, vol. 122, no. 2, pp. e305–e317, Aug. 2008. https://doi.org/10.1542/peds.2007-3134

[27] Cole, Steven W., Yoo, Daniel J., and Knutson, Brian, "Interactivity and reward-related neural activation during a serious videogame," PLoS One, vol. 7, no. 3, p. e33909, 2012. https://doi.org/10.1371/journal.pone.0033909

[28] Peters, Konrad, Unterbrunner, Alexander, Martinek, Daniel, Hofmann, Alexander, and Hlavacs, Helmut, "Feasibility of Physiotherapy Exercise Capturing using a Low-Cost Motion Capture System," in International Conference on Computer Games, Multimedia & Allied Technology (CGAT). Proceedings, 2016, p. 47.

[29] Kayali, Fares et al., "Design considerations for a serious game for children after hematopoietic stem cell transplantation," Entertain. Comput., vol. 15, pp. 57–73, 2016. https://doi.org/10.1016/j.entcom.2016.04.002

[30] Hlavacs, Helmut et al., "Usability and Fun of the INTERACCT Client," in eHealth 360°: International Summit on eHealth, Budapest, Hungary, June 14-16, 2016, Revised Selected Papers, Giokas, Kostas, Bokor, Laszlo, and Hopfgartner, Frank, Eds. Cham: Springer International Publishing, 2017, pp. 156–163.

[31] Peters, Konrad et al., "Serious Game Scores as Health Condition Indicator for Cancer Patients," Stud. Health Technol. Inform., vol. 210, pp. 892–896, 2015.

[32] Samwald, Matthias, Fehre, Karsten, de Bruin, Jeroen, and Adlassnig, Klaus-Peter, "The Arden Syntax Standard for Clinical Decision Support," J. Biomed. Informatics, vol. 45, no. 4, pp. 711–718, 2012. https://doi.org/10.1016/j.jbi.2012.02.001