Virtual Coaching Activities for Rehabilitation in Elderly

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Project Whitepaper

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vCare: Driving Virtual Coaching beyond the State-of-the-Art

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Document history

Version	Date	Author/Editor	Description
0.1	07.12.2018	Hannes Schlieter, Carola Gißke, Kai Gand (TUD)	Initial version
1.1	17.12.2018	Hannes Schlieter, Carola Gißke, Kai Gand (TUD)	Version considering initial comments by consortium members
1.2	18.07.2019 21.08.2019	Hannes Schlieter, Carola Gißke, Kai Gand (TUD), Sofoklis Kyriazakos (iSprint)	Extensions in order to act as the project's conceptual brace to a greater extent

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1 Introduction and Primary Objective

The primary aim of this document is to sum up the essentials of vCare's virtual coaching system on a conceptual level. This is to provide a baseline for the work to be done to properly implement the DoA and to serve as internal consent about the interlinkages of the project's single components and sub-topics.

First of all, it is important to re-call in mind that the project is about to solve a medical issue (rehabilitation/recover quality of life (QoL)) by technical means (the virtual coaching solution). Therefore, the main question is how the virtual coach can help and support the rehabilitation plan as set by the clinicians (see Figure 1).

Key Stones:
1) Focus on **the user experience using a virtual coach in a home environment** to supplement the regular rehabilitation processes
2) **Integrate suitable solutions under the umbrella of the virtual coach** (guided by the physician)
3) The innovation goes beyond driving one single solution or technology (not only, but utilizing and combining telemonitoring, context integration)

Additionally but still for the sake of the patients' rehabilitation progress, the vCare project aims to go beyond the state-of-the-art technology integrating and processing different data sources to personalise the coaching recommendation based on clinical pathways and patient preferences.

Therefore, ***the project mission is to utilize the virtual coach as communication mean for the patient. Acting like a physical coach, the VC channels the information and provides suitable recommendations to the patient, as well as engages the patient "like a coach" to stay in their "training plan" and also provides a backlink of the outcome as well as a possibility of intervention to the physician. On that basis, the virtual coach's features as the vCare project's core concepts are designed.***

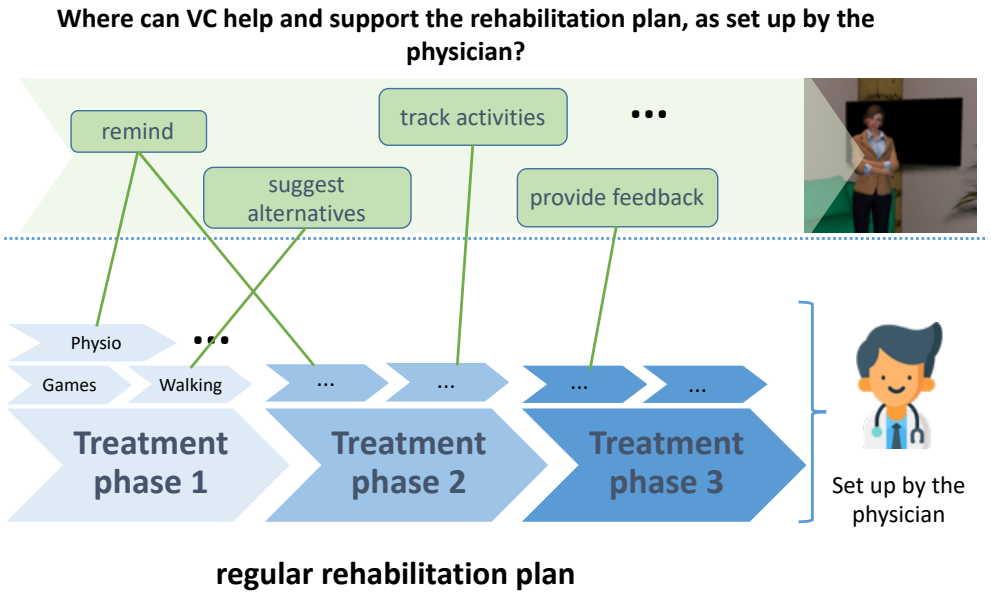

Figure 1: Virtual Coaching as a support for the rehabilitation

2 vCARE'S UNIQUENESS – CORE CONCEPTS

2.1 STATE OF THE ART REVIEW

New ICT based concepts for empowering and motivating people can help them to proceed with a personalized rehabilitation that complies to age related physical, cognitive, mental, and social conditions. Actually, the major disadvantages of home-based rehabilitation solutions are the lack of specialized equipment and insufficient alignment and adaptability of the technical possibilities to the individual care needs and abilities. In this context, the so-called "Virtual Coaches" are seen as a key driver for health promotion in home care settings. The technological possibilities have massively evolved over last decades.

In the literature, several studies have analysed the interaction between Virtual Coaching and users in various clinical settings and for different purposes. We have focused our selection on those studies that are dominant and throughout the years remain reference points in this field. In [1], it has been highlighted that one of the greatest areas of innovation for Virtual Coaching was to support preventative health management and self-care. They believed a new class of intelligent devices and applications could have facilitated self-management, users' compliance and prevention of secondary conditions in the field of rehabilitation.

In [2], it was demonstrated a sustained level of activity in overweight adults provided with a Virtual Coaching in addition to a pedometer and web-based feedback, compared with a decline seen in those without Virtual Coaching was demonstrated. Even the use of an e-coach support to help users keep their weight under control [3], [4], or the development of an intelligent virtual agent (i.e., Embodied Conversational Agent – ECA) to persuade people to improve their eating habits [5] have provided promising results.

In [6], it was shown that VCs and comfortable human–computer interfaces, based on user-centered AI approaches, could promote active information processing and adoption of new thoughts such as motivation and behaviour changes. The immediacy of communication appears to be a particularly important aspect of effective e-health communication. However, high quality e-health communication programs depend more on the appropriateness and dynamism of the messages exchanged than merely on the digital channels used for communicating.

Interesting is a single case presented in [7], where a powerlifter, with long-distance coaching by the cardiac rehabilitation staff, returned to his sport after coronary artery bypass grafting. Through high-intensity training that was complemented by phone and e-mail support, he lifted heavier loads than he had before the bypass grafting. Concerning the cardiologic disease, in [8] a study was conducted on the use of the system and readmission outcomes of a pragmatic randomized trial of E-Coach in a diverse sample of complex adults with heart failure (CHF) and chronic obstructive pulmonary disease (COPD) from a wide geographic region in the southern USA. Although 30-day re-hospitalization rates did not statistically differ between the e-coach and usual post-discharge care groups, in the COPD subgroup, e-coach was associated with significantly fewer days in the hospital indicating that interventions may need to be disease-specific to increase effectiveness in decreasing re-hospitalization rates and increasing adequate post-discharge care.

This efficient and low-cost approach offers an innovative opportunity to improve patient/clinician partnerships in managing chronic conditions, in particular in the improvement of patient–clinician communication [9].

In the universe of the elderly population, [10] and [11] evaluated the efficacy of an automated intervention with the ECA to improve physical activity and fruit and vegetable consumption in sedentary older adults showing an effective result at changing health behaviour by this computer-based program. Other authors [12] used ECA for engaging elders in regular physical exercise. Results showed a substantial potential to reduce the health disparities gap by influencing a key health behaviour in underserved populations. Additionally, it has been studied how the older adults could interact with a pet avatar: a pilot study [13] was conducted to examine the perceived acceptance and utility of a tablet-based conversational agent in the form of a pet avatar used by older adults during daily interactions over three months. The results disclosed that this interface (i.e., a digital pet) could provide older adults with companionship and enhance social interaction. Recently, the ECA applications in clinical psychology have been reviewed, but the authors concluded that these applications are still limited [14].

Although the literature on Virtual Coaching still reports a limited number of subjects involved and few clinical conditions investigated, data on the use of internet-based coaching are encouraging and show that people can get used to electronic communication in order to take advantage of it for their state of health. In this scenario, new studies on these innovative and intelligent solutions are necessary. In particular, for patients with disabilities due to chronic neurological and cardiological conditions the Virtual Coaching system is the preferred solution to activate personalized rehabilitation programs at home that can guarantee continuity of care outside hospital facilities.

Further to the scientific literature, several research projects integrate technology of Virtual Coaching, such as (see EC's related PM-15 project call): Wellbeing and Health Virtual Coach (WellCO), is a virtual coach that is intended to cater of seven areas of human health, namely: cognitive stimulation, leisure and entertainment, support groups, physical activity, health status, nutrition and tips [7]. These areas pertain to a whole range of age groups and reflect a person's well-being in any condition. Whereas, holograms for personalized Virtual Coaching and motivation in an ageing population with balance disorders (HOLOBALANCE) is a personalized coaching solution for people with balance disorders mainly concerning with age-related progressive loss of sensory information [15]. Empathic, Expressive, Advanced Virtual Coach to Improve Independent Healthy-Life-Years of the Elderly (EMPATHIC) is a virtual coach to engage healthy senior users to take care of their lifestyle with a significant degree of independence [16]. The solutions help to take care of chronic diseases and follow a healthy diet with adequate physical activities by integrating the user with sufficient social functions. The Council of Coaches is another EU H2020 project that provides conversational agents that enable fluent multi-party interaction between multiple coaches and users, thereby changing the coaching paradigm [17]. Novel Empowering Solutions and Technologies for Older people to Retain Everyday life activities (NESTORE) is a behavioural based iterative Virtual Coaching, which plans the coaching schedules based on mood and environment [18]. NESTORE is an elderly oriented solution that promotes healthy ageing and is committed to user privacy. Coach Assistant via Projected and Tangible Interface or CAPTAIN is a Human-Computer Interface with radical approaches, such as augmented reality, for non-invasive collection and analysis

of emotional, behavioural and physiological data and has a motivational engine to guide users for healthy diet and exercise tips, cognitive activities and social interactions [19]. Supporting Active Ageing through Multimodal Coaching, as the name suggests, is a server and client sided platform for specialized well-being monitoring and assessment. The platform endorses ambient data collection requiring minimal user input with immense ease of use. Widening the support for large-scale uptake of Digital Innovation for Active and Healthy Ageing (WE4AHA) shall build a thorough set of promotion and support services that will embellish the use of Digital Innovation for Active Healthy Aging (AHA) [20]. Through WE4HA the relevant stakeholders will be able to develop and implement three EU guided activities, namely innovation to Market (I2M) [21], Blueprint Digital Transformation of Health and Care for the Ageing Society, and EIP on AHA.

The vCare approach is an end-to-end process that has capability to revive a person back to his or her normal life, and adds value compared to the state-of-the-art. Further, vCare system is deluged with several sensors accompanied with intelligence to evaluate patient's health status, medical adherence, and other factors that are necessary for smooth recovery and in maintaining the quality of life post-treatment. It also provides interfaces for both caregiver and patient for them to connect and communicate with each other, and for caregiver to extract patients' relevant information without bothering them.

a) Patient's best pal: It is almost impossible to be with a patient every time, and if it possible, then it is a fairly expensive deal. vCare, for its intensive use of 'internet of things', relieves both patient and healthcare system from a constant bother. This makes patient feel more independent, and as well as connected with the healthcare system at the same time.
b) Light on Economy: vCare is a strong proponent of need-based availability in the rehabilitation processes, meaning that a patient is attended by practitioners only when it is required. This saves a lot of quality hours of the medical and healthcare system, which decreases the costs of the health system overall.
c) Only truth prevails: We intend to permeate the vCare system with ample intelligence to filter out false alarms and unnecessary nagging of the patient. In old age and during recovery from traumatic conditions, patients may have irrational apprehensions, many of them could be solved just by proper communication and consultancy and need of physical presence can be avoided.
d) Avalanche of applications: Being intelligence and IoT based system it has a polymorphous nature. The rehabilitation process shall be more innovative and timely. Based on the information received from the monitoring system, the dozes, diets, exercise schedules, etc. can be altered on daily and even hourly basis, instantly. This adds more flexibility and dynamics in the caregiving process. The sensing can also be used as mood indicators, swings and behaviour monitoring, which puts vCare above other rehabilitation systems. We can customize vCare system to involve a patient in any other extra activity that practitioner may find suitable for a patient. We can set vCare system with schedulers and time watchers to inform or remind a patient about taking medicine, going for a walk, or even favourite TV series.

vCare is therefore an innovative, extensive, and holistic rehabilitation system, which not just focuses on restricting a patient to rehabilitation path, but allows them to smoothly transit from trauma to triumph. In the following section, the uniqueness of vCare is presented with its core

concepts and achievement of adaptiveness and personalisation by means of the Virtual Coach.

2.2 Core Concepts

Unfortunately, the continuity of the rehabilitation process often interrupts with the transition to the home environment. Nowadays, the major disadvantage of home-based rehabilitations is the lack of appropriate solutions meaning that neither specialized equipment nor the alignment and adaptation of the technical possibilities is done with respect to the individual care needs and abilities. Rehabilitation guidance by a virtual coach does not replace specialists but rather supplements their work to guarantee the continuity of care in the home environment and daily life where current rehabilitation programs often fail because of the lack of continuous assistance.

Core Concepts:
1) Facilitate the continuity of care by a set of virtual coaching services as supplement to classical rehabilitation
2) Maintenance of quality of life: adherence to care plan and reduction of risks
3) Ongoing personalization of rehabilitation program based on user behavior, preferences, conditions, context, and pathway
4) Continuous improvement via AI
5) Virtual coach as the mean for communication
6) Technical advances to be made on prior European initiatives

Therefore, the vCare project develops and investigates a new ICT-based concept, encapsulating a set of coaching services for empowering and motivating people, helping them to proceed with a personalized rehabilitation that complies to age-related physical, cognitive, mental, and social conditions by a virtual coach.

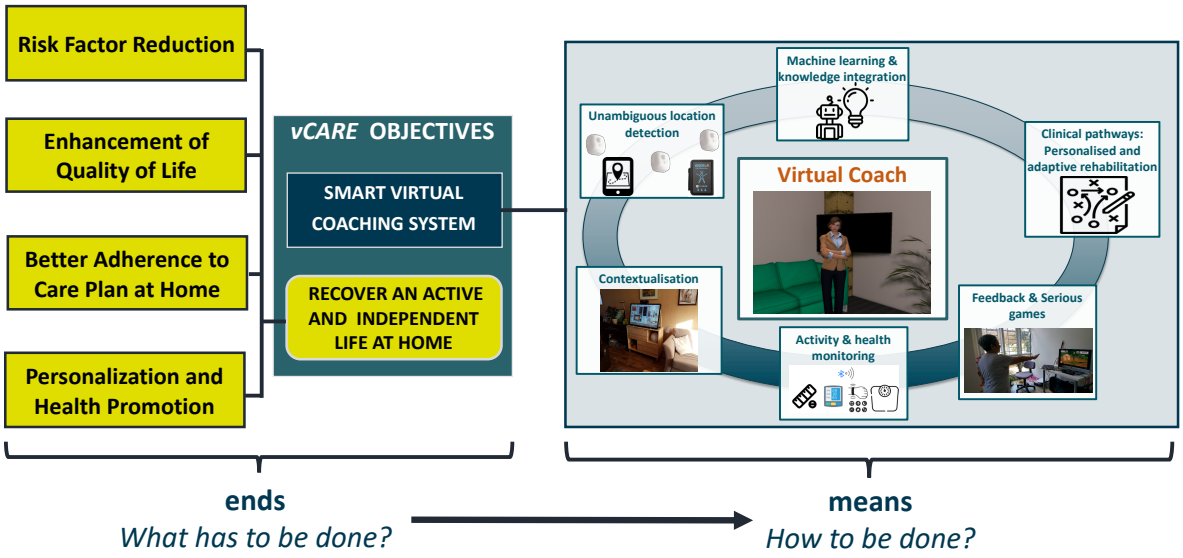

Figure 2: vCare's ends and means

In particular, utilizing the virtual coach aims to enhance the QoL of people by helping them to adhere to the care plan that provides personalized recommendations for the daily activities. The coaching will lead to a continuous reduction of risk factors that are related to the probability of a relapse of the disease, the manifestation of disabilities, or the decline of (mental) health (see Figure 2).

vCare monitors the patients' daily activities, conditions, and habits to provide personalised feedback to recover the QoL. For that, the coaching programmes are initialised by specialists by assigning a well-elaborated clinical pathway as a tailored rehabilitation plan to the patient (in accordance with the personal context information, and specific patients' needs). According to this plan, vCare enables the personalization of the intensity and way of interaction and will trigger suitable exercises (serious games, cognitive training programs, etc.), suggestions and feedback. Additionally, the context information that helps to monitor daily life activities and individual habits will be integrated.

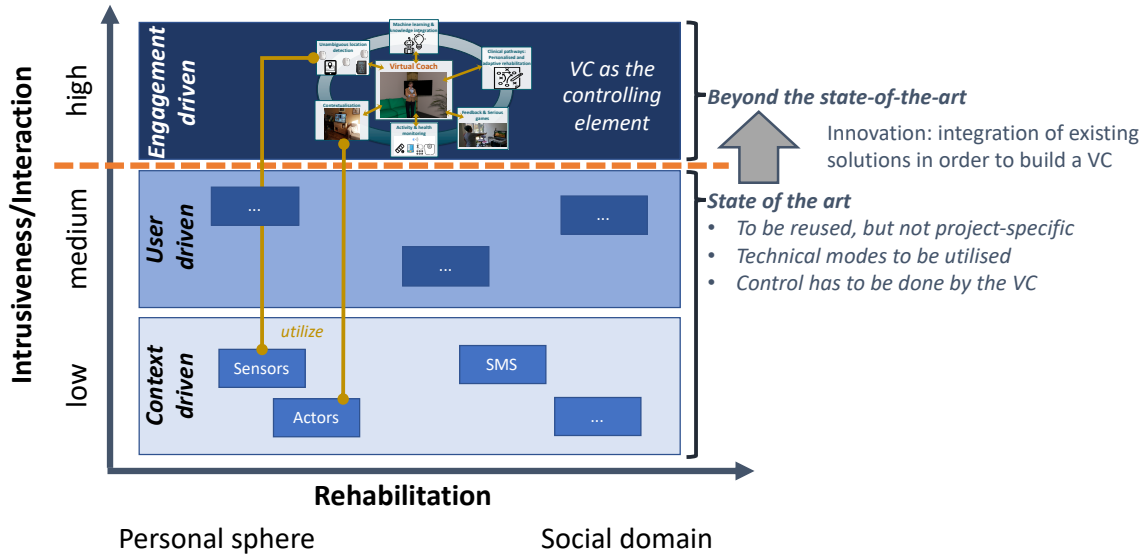

Figure 3: Meaning of "beyond the state-of-the-art" – USP of vCare

vCare will advance the current state-of-the-art significantly by integrating semantic technologies (reasoning, behavioural models, predictive analytics, going beyond only rule-based but more intelligent adaptations), well-elaborated coaching services and clinical pathway services having the virtual coach as the central and controlling element (see Figure 3).

vCare channels the interaction with the patient at home via a virtual avatar, which communicates mainly, but not exclusively, via natural speech communication. Alternative modalities depend on the users' preferences or context.

Ambitions:
1) Integration of semantic technologies (reasoning, machine learning, behavioural models, predictive analytics) to build a virtual coach experience beyond the state-of-the-art
2) Integration of well-elaborated services to provide a holistic solution
3) Continuous adaptation to patients' needs and context

The VC encapsulates coaching and supportive services as well tele-monitoring services. The latter provide the data-related basis for the virtual coach's decision logic and as well as tracing data the service provision is based on.

However, the innovativeness of vCare does not only reside in the utilization of single technologies but in the combination of these technologies (see Figure 4). This is to individualise/personalise the home care/rehabilitation and somehow fill the gap the caregiver's absence has caused.

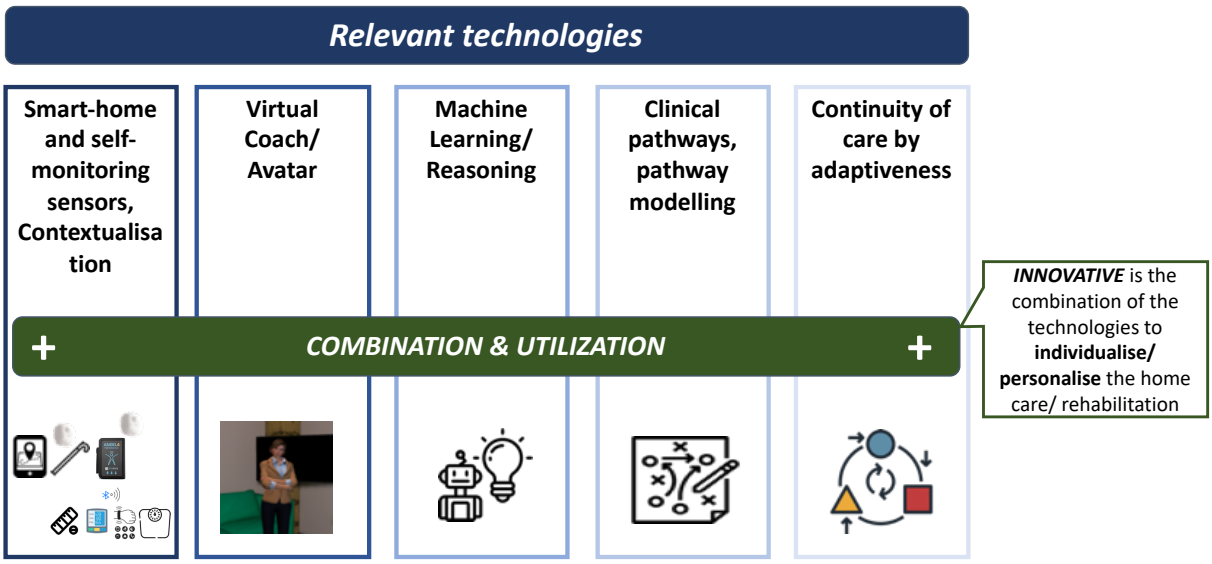

Figure 4: Combining different technologies as an innovative element of vCare

2.3 Adaptiveness and Personalisation by means of the Virtual Coach

Refraining from static rehabilitation programmes (that might be feasible in the inpatient sector), the continuous adaptation to patients' needs and context ensures the patients' empowerment to adequately deal with their circumstances. The system focuses on the change of people's attitudes and behaviours towards a healthier lifestyle and support the elderlies in their everyday rehabilitation activities and support a better therapy adherence. In general, there would be two options in case a patient leaves the desired range (see Figure 5 for an overview). Firstly, the physician could intervene and take measures to come back on track. Admittedly, the physician has a great expertise and abilities to do so but is also not at the patient's site and examines him/her only occasionally (given the case of home rehabilitation). Secondly, the Virtual Coach could intervene as it is in immediate proximity and permanently examines the patient. The Virtual Coach's limited expertise has to be compensated by means of providing medical knowledge, sequence plans or interaction schemes in terms of modes that are usable for the Virtual Coach. This relates to clinical pathways (as the representation of the adequate treatment procedure), smart-home sensors (replacing the eyes of a human caregiver) or sensors for vital data, the avatar itself (replacing the caregiver's face and interaction possibility) or the machine learning and reasoning (replacing the human's assessment abilities).

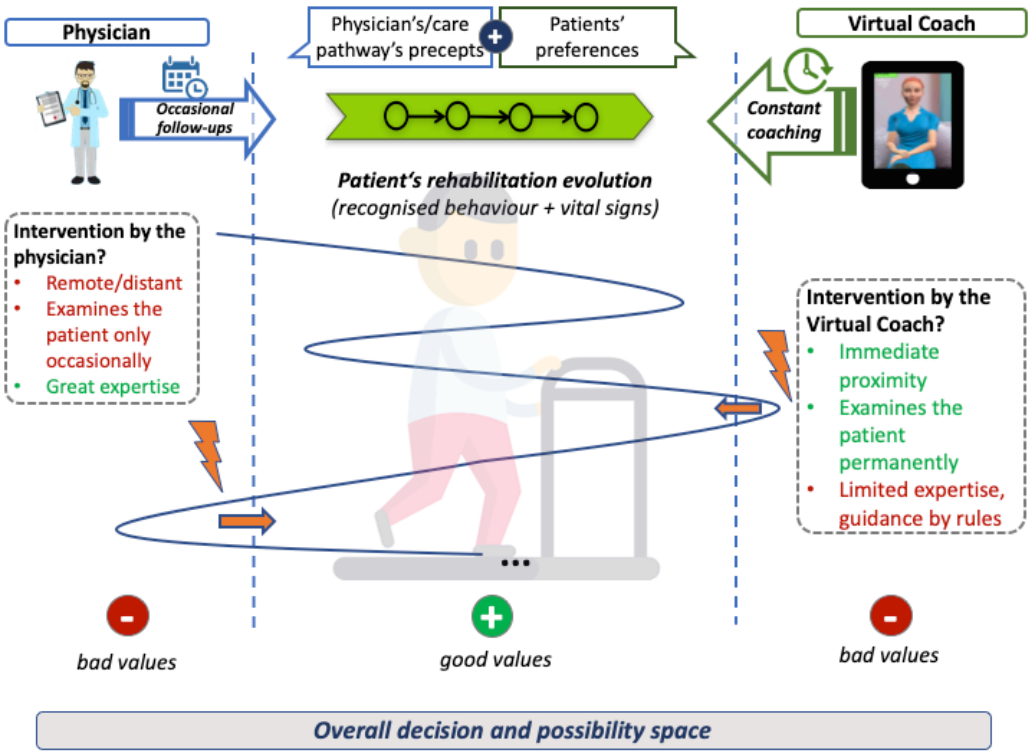

Figure 5: Decision and possibility space and respective possible interventions

The technical concept of vCare ties up to the preliminary contributions of former European initiatives like *universAAL* (*ReAAL*) and *FI-WARE*, and *Miraculous Life*, *DoReMi*, or *eWall* by reusing and building upon this technical groundwork. We will use these to adapt and reuse virtual coaching services that suite to our clinical use cases. The major advance of the vCare concept is an adaptive integration and use of these services according to a personalized pathway. All services, devices and sensors can be (re-) composed and re-configured if needed. The knowledge layer's agents address use cases by making recommendations. Moreover, the knowledge layer's ontology contains the information about the patients' needs and conditions, services, and pathways. The ontology gives the input for the ML algorithms that analyse the compliance, and progress of the patient in comparison to his/her pathway. Depending on the result, adaptations of the former pathway can be proposed.

3 Stages For Virtual Coaching - "Life Cycle"

The vCare's virtual coaching approach can be conceptualized as a continuous life cycle model as illustrated in Figure 6. Before the actual coaching activities in the patient's home environment begins, a *clinical assessment* at the end of the inpatient rehabilitation phase defines a concrete patient profile, which helps to define or to choose the setup of an individual patient pathway.

After the adaptation of the pathway according to the patient's needs and the release into the home environment, a basic infrastructure of sensors and devices are set up in the patient's home that are required for all monitoring and supporting activities performed by the virtual coach (*pathway set up*).

Afterwards, the virtual coach can start developing and communicating the daily routine for the patient in accordance with the available context information. Only for the initial iterations the cold-start problem has to be resolved. This means that guidelines are required in order to pre-train the agents for assigned use cases. As soon as the ML models are trained, the VC can start developing and communicating the daily routine. Further on, the rehabilitation activities will be personalized dynamically within preconfigured thresholds and occurring exceptional events. This may also lead to an adaptation of the underlying pathway or a new clinical assessment, which then initiates a new pathway set up until a predefined rehabilitation goal is achieved.

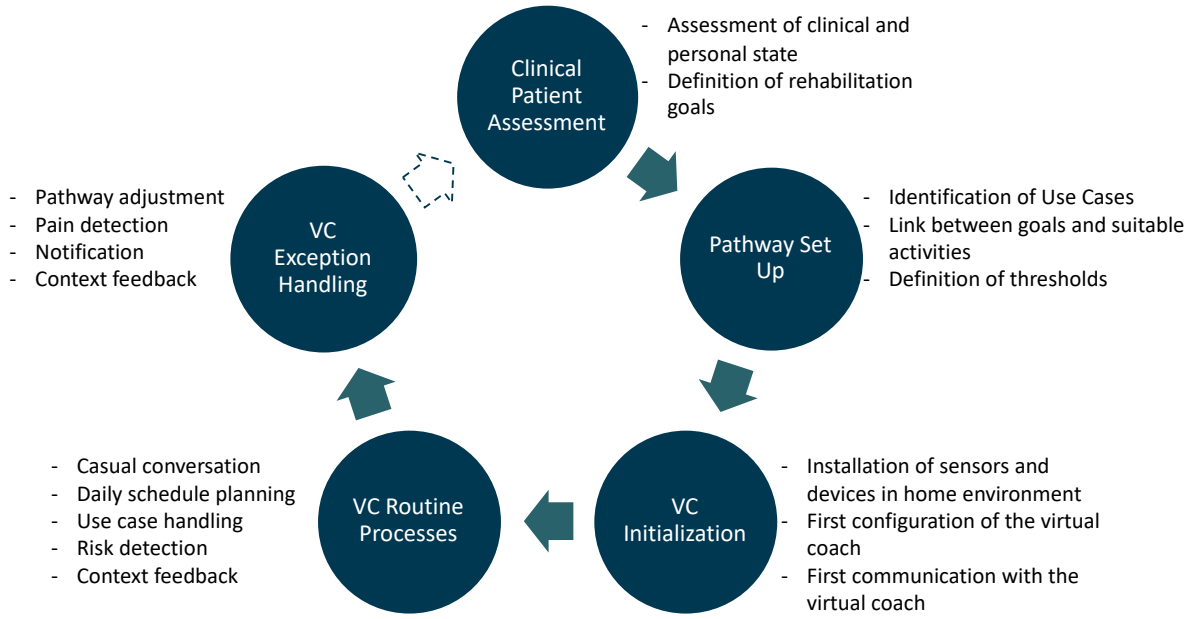

Figure 6: Stages for Virtual Coaching

The clinically relevant coaching elements or process steps are described by medical use cases that are used to design the respectively needed technical functionalities of the VC solution. A detailed description of the stages for the virtual coaching approach is given in the following.

3.1 Clinical Assessment and Set Up of the Patient Pathway

At the end of the inpatient clinical rehabilitation phase (before the patient's shift from the hospital to the home environment), the attending physicians perform an **assessment of the patient's clinical state** regarding his or her motoric, cognitive, neuropsychiatric and general health conditions, as well as the personal state considering level of independence along with habits and preferences. This is illustrated in Figure 7 as number 1.

According to this patient profile, **rehabilitation goals are defined** that serve as guideline for the outpatient rehabilitation phase at home. Indicators on how to measure/assess the achievements of long-term and short-term goals are defined. The physician then can choose an appropriate pathway template that fits the patient profile and modify this according to the patient's needs (see Figure 7, no. 2).

Therefore, **a set of (virtual coaching) use cases[1] is identified**, that define goal states in order to achieve the rehabilitation goals. Each use case contains a collection of suggested activities as well as thresholds for vital signs or risk behaviour defined by the physician. These use cases in context with the patient profile as well as the environmental circumstances serve as a basis for the virtual coaching activities, i.e. the choice of the appropriate use case during the patient's daily routine (see Figure 7, no. 3).

During the rehabilitation phase at home, the **use cases can be updated** according measured or recognised states (see Figure 7, no. 4). This is basically done by adapting the baseline thresholds or guideline rules based on the performance of the patient. This is done by that are able to change these baseline values according to given equations provided by medical domain experts.

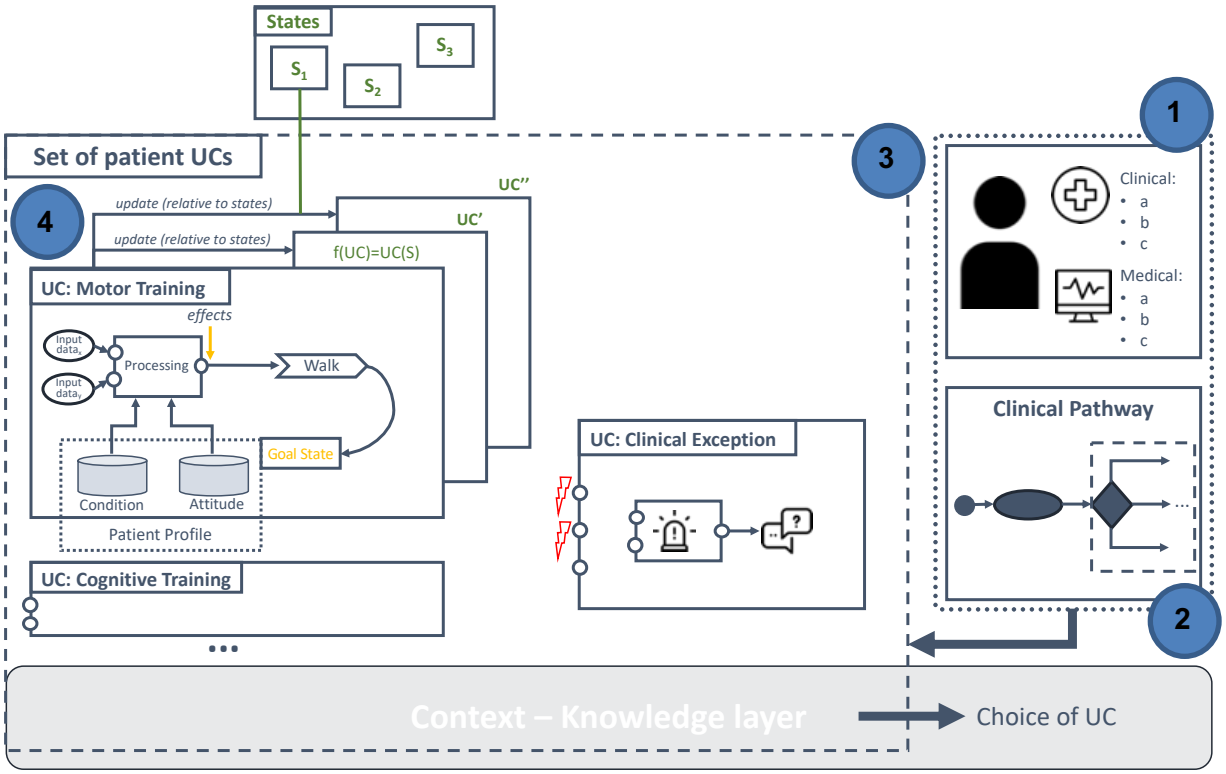

Figure 7: Simplified overview and scenario-based description of the VC approach

3.2 Initial Virtual Coach Set Up in Home Environment

With the return of the patient into the home environment, a set of sensors and devices needs to be set up in the patient's home. That includes necessary sensors for the monitoring of indoor activity and vital signs and also devices like a tablet for the interaction with the virtual coach or the necessary set up for the use of serious games as training sessions.

[1] This is explicitly called a „virtual coaching" use case to highlight that it is not similar to the medical case or medical use case that is linked to the patient profile. A medical use case can be connected to several fitting virtual coaching use cases.

The virtual coaching system needs to be configured according to the underlying patient pathway. There will be a scenario for the first time of interaction between the patient and the coach, that introduces the coach and its role as a supportive element during the rehabilitation at home.

3.3 Regular Interaction / Routine Process

The daily routine between the patient and the VC is characterized by interactions that support the patient in adhering to the suggested rehabilitation plan, supervising indoor activities and thus identifying risk behaviour and habits and thereby providing assisting advices or alert messages.

This will be realized by the adequate choice of distinct use cases according to the patient pathway and available context information as illustrated in Figure 7. The following tables demonstrate typical scenarios of interaction that might occur during a regular course of the day and the involved system components.

Scenario 1: Daily schedule planning and choice of suitable trainings

Kind of interaction/ intervention	**Way of interaction**	**Considered context information**
Detecting patient's mood	- Direct with speech recognition - Facial recognition	- Personal state
Scheduling of training activities	- Direct with speech recognition - Visualisation on screen with options to choose	- Pathway information - Clinical state/health status - Personal state regarding habits - Patient's preferences - Weather forecast
Adding additional non-training-activities	- Direct with speech recognition - Manually by the patient	- Patient's preferences

Scenario 2: Training session performance

Kind of interaction	**Way of interaction**	**Considered context information**
Training session reminder	- Message	- Time schedule
Choice of activity or proposition of alternatives	- Direct with speech recognition - Visualisation on screen with options to choose	- Suggested activities in use case - Patient's preferences - Weather forecast
Feedback about last/ after a session	- Visualisation of results and trends (Request for time series data) - Motivational message	- Learning curve - Activity observation features with reference to a goal state - Vital signs evaluation - Wiki

Feedback during training session	- Direct message if wrong execution (in comparison to the set baseline/expectation) - Alert sound when almost reaching a threshold	- Vital signs/ activity monitoring with reference to defined threshold - Wiki

Scenario 3: Behavioural advices regarding risk behaviour

Kind of interaction	Way of interaction	Considered context information
Risk detection / warning event	- Send alert sound - Provide message with behavioural hints	- Indoor activity monitoring - Clinical state regarding health status
Promoting risk awareness	- Behavioural hints - Video tutorial	- Analysis of warning events - Personal state (known/detected patient habits)

3.4 VIRTUAL COACH EXCEPTION HANDLING

Next to the definition of use cases for achieving rehabilitation goals, use cases for clinical exceptions need to be identified. These contain thresholds for physical activity or risk behaviour and appropriate activities, which can be performed in case an exception is detected. Exceptional procedures (interrupting the regular VC interaction) need to be defined by the physician and could include an adaptation of the pathway by the virtual coach or the transmission of an alarm to the physician, possibly combined with a request for feedback or to restart the virtual coach activities (e.g., when the vital parameters are beyond the foreseen thresholds caused by a particular training, the physician could be alarmed or asked for an adjustment of the pathway).

Scenario 4: Ongoing bad training performance

Kind of interaction	Way of interaction	Considered context information
Adjustment of training session parameters (intensity, duration)	- Message about adjustment	- Defined rules in Knowledge Layer - Learning curve - Clinical state reg. health status
Notification for caregiver	- Message about training performance and adjustment - Request for feedback	- Information about attending physician (on the basis of the role and contact information)
Training feedback	- Motivational message	- Learning curve - Reference to defined goal states - Wiki

Scenario 5: Exceptional event during training session (threshold exceeded, pain, fatigue, etc.)

Kind of interaction	Way of interaction	Considered context information
Interruption/ post-ponement of session	- Message about modification	- Pathway information

Pain / mood detection	- Direct with speech recognition - Visualisation on screen with options to choose	- Clinical state regarding health status, measurement scales
Feedback	- comforting message - behavioural advices	- Wiki
Notification for caregiver	- Message about exceptional event - Request for feedback	- Information about attending physician

3.5 INTENDED BEHAVIOUR AND INTERACTIONS OF THE VIRTUAL COACH

Figure 8 summarizes the intended behaviour and interactions of the virtual coach. These can be characterized as follows:

- **Training guidance (coaching services)**: By means of machine learning algorithms, the VC will consider all available information provided by daily monitoring, medical indicators, the underlying patient pathway and context information (calendar, weather) and *choose an appropriate training activity* as well as *suggesting suitable alternatives*. It will *monitor defined parameters* during the exercise and *provide personalised feedback* during the activity in order to correct false execution, as well as after an activity with motivational purpose. The VC will keep track of the rehabilitation's evolution and *adapt activity parameters* (goals, limits) according to the progress achieved. In *case of an emergency*, the VC can *react properly to the situation* and *notify help*. Moreover, the VC will provide caregiver and physician with steady *reports*.
- **Daily monitoring and support (context/data services)**: The virtual coach monitors the daily activity of the patient and thereby, can *identify habits and risk behaviour* as well as *social interaction*. If necessary, the VC can intervene in hazardous situations and *send an alert*. With the help of *reminder messages*, the VC will help the patient adhering to scheduled dates, *provide counselling* if requested (e.g. with e-learning lessons) and *encourage social relations* to others.
- **Pathway adaptation (context/data services)**: In the course of therapy, the virtual coach will be able to consider learnt knowledge about the patient's habits and preferences. By means of machine learning algorithms, the system will be able to change the underlying pathway according to the patient's needs. This does not comprise the adjustment of activity parameters, but actual changes of the process flow, e.g. by adding/excluding activities to the initial pathway. However, this does not exclude manually made adaptations or change approvals by the responsible physician.

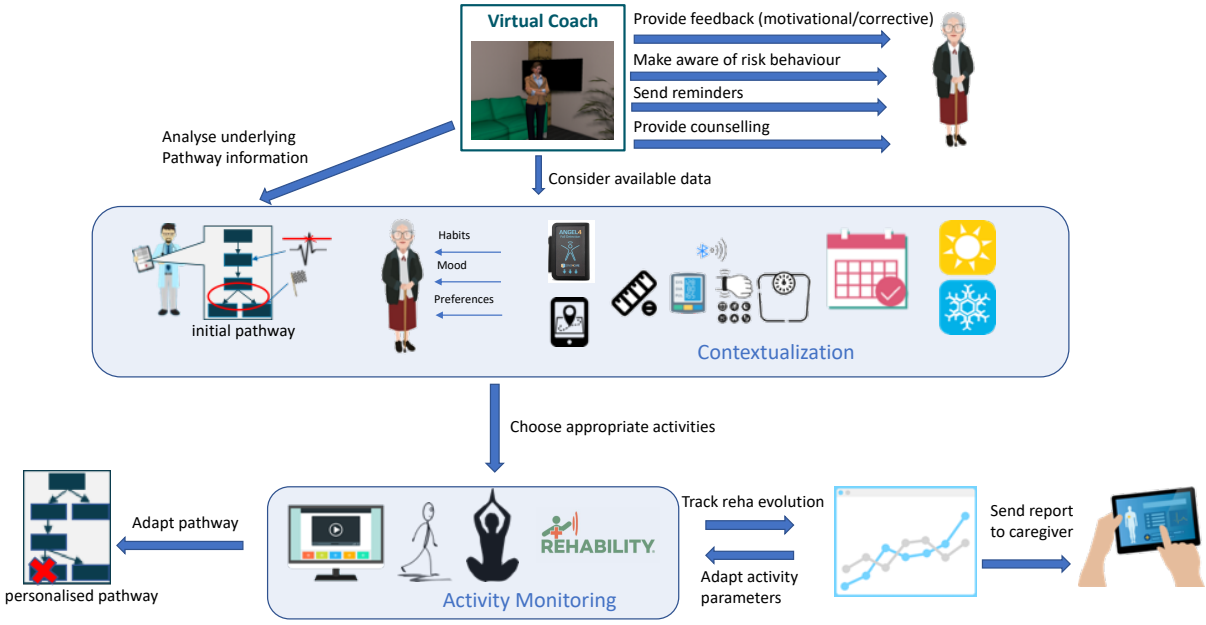

Figure 8: Scope of action of the virtual coach

The interaction between the VC and the patient will be described in medical use cases related to each pathology addressed in the project in **D1.2**. These medical use cases will, thereby, demonstrate the intended personalised behaviour according to the patient's needs and set the scope of action of the VC. Within **D1.4**, the medical use cases will be linked to a set of virtual coaching "use cases" which are prescribed throughout the selection of the pathway for the patient. Furthermore, **D1.4** will provide all the information necessary in order to model pathway templates for each clinical site, including e.g. executable activities, associated observation features and time events, that serve as a baseline for the initialisation of the patient's rehabilitation plan. In addition to that, **D1.3** will present rules and mechanisms that are necessary for the dynamic adjustment of activity parameters, i.e., goals and limits, according to the actual therapy progress. Thereby, D1.3 and D1.4 are providing all the information necessary for the machine learning algorithms which will help to change the initial pathway at the beginning of the therapy into a personalised one by adaptation in the course of the therapy process and thus, defining the clinical scope.

4 Interplay of the Project's Main Components and Work Structure

The primary interaction of the major clinical deliverables and the technical ones having D1.4, D5.1 and D7.4 as the informing core deliverables is shown in Figure 9: Relation of the clinical and technical core documents. The further particular technical developments and the respective outcomes/deliverables after agile iterations/adaptations during the joint testing phases as well as the further clinical study concepts and evaluations are however excluded from this overview for the sake of clarity.

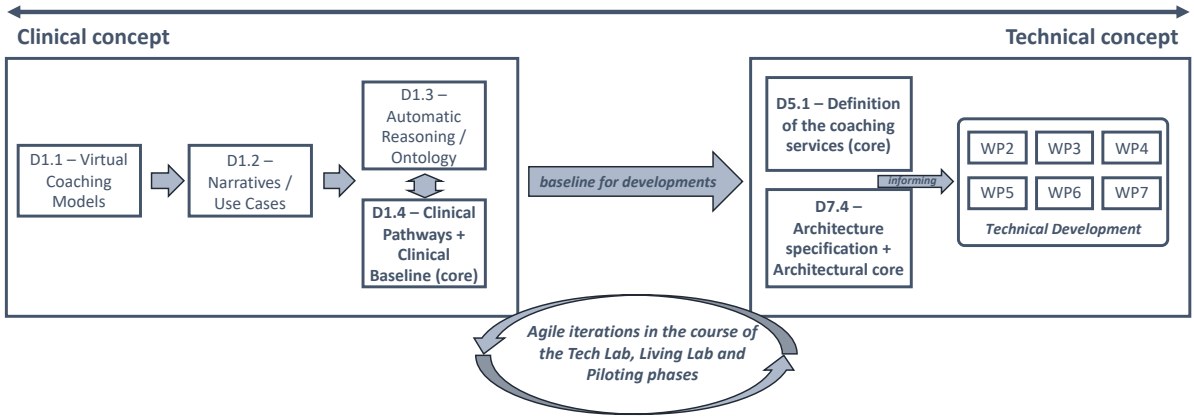

Figure 9: Relation of the clinical and technical core documents

To conceptually better overview the technical main components relevant within the vCare project, Figure 10 provides first insights in the needed elements to fulfil the project's obligations as set by the main objectives (see section 2.2).

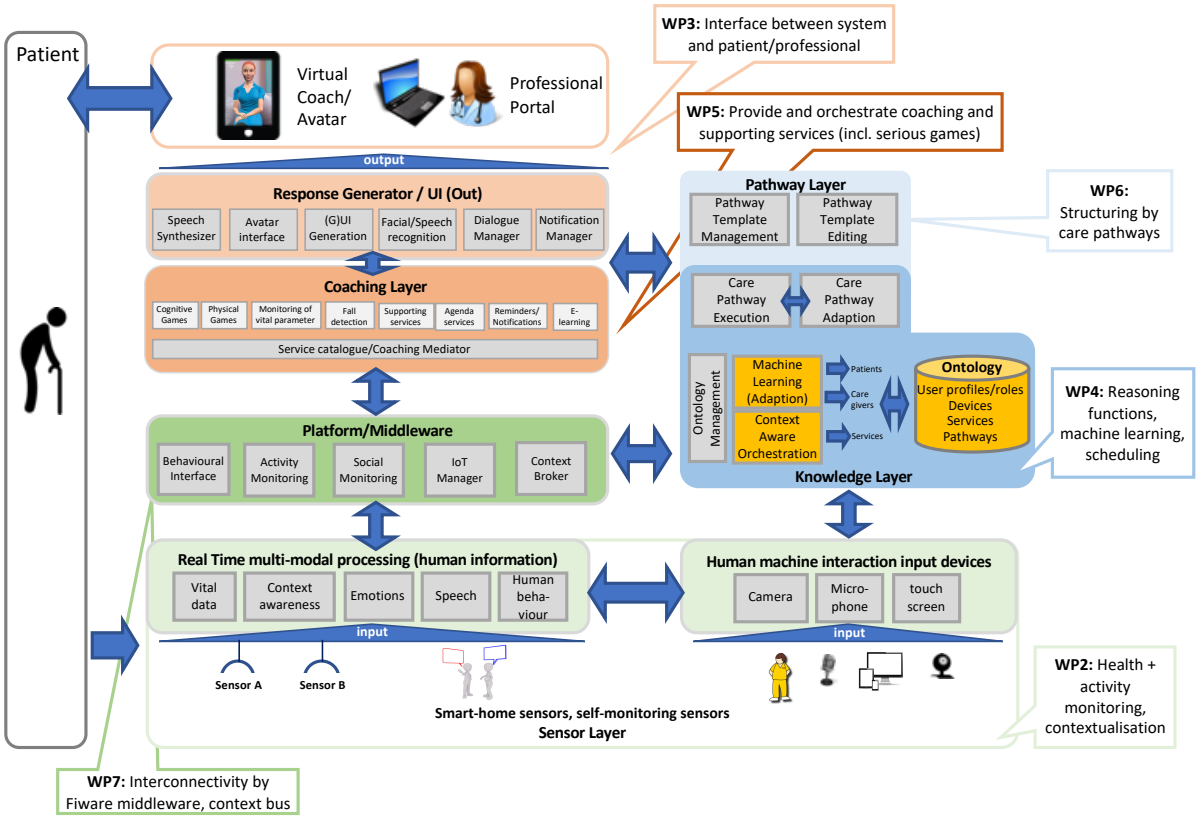

Figure 10: Overview of the primary technical components

The components' interplay describes the general conceptual approach how the main building blocks are connected and communicate to materialize the virtual coaching experience in the patients' home environment. A system of well-formed and inter-connected components gathering, processing and providing information lead to an appropriate virtual coaching solution. The clinical scope defined in WP1 will serve as a basis for the derivation of the other WP's content. In WP2, necessary sensors and devices for the health and activity monitoring as well as their interconnection will be derived. The interaction between the system and the

end users in terms of an avatar and a professional portal will be displayed in WP3. The reasoning functions of the knowledge layer that are building the baseline for the machine learning algorithms will be described in WP4 with direct reference to D1.3. Coaching and supporting services that support the personalised rehabilitation plan set by the clinicians will be defined in WP5 (having D5.1 as respectively informing core deliverable). The clinical information of D1.4 will be used to derive pathway templates for each medical case. Finally, the interconnectivity of all technical components will be displayed in WP7. Especially D7.4 will provide a final baseline of the vCare architecture and release plan for the various phases of the vCare project.

In order to give an example of the component's interplay, Figure 11 illustrates a typical communication case including the communication sequence among the main building blocks. Given the case that the patient asks for the overview of his or her daily agenda: He or she switches on the avatar and asks via speech for the forthcoming session ((1) in Figure 11). The speech will be processed and converted to a request, that will be routed to the appropriate service, i.e. agenda services.

This service will send the request to the knowledge layer ((3) in Figure 11). According to the context information, current health status, stored preferences and pathway ((5) in Figure 11), the knowledge layer will update the daily agenda and provide this information back to the coaching services, which will "trigger" the computerized avatar to explain the daily agenda (depends on the current context (state) of the patient and fixed appointments, e.g. doctor's appointments) while the list of to-dos will also be rendered beside the coach. A possible follow-up can be that the avatar is now proposing a short training session to make an exercise for the cognitive abilities.

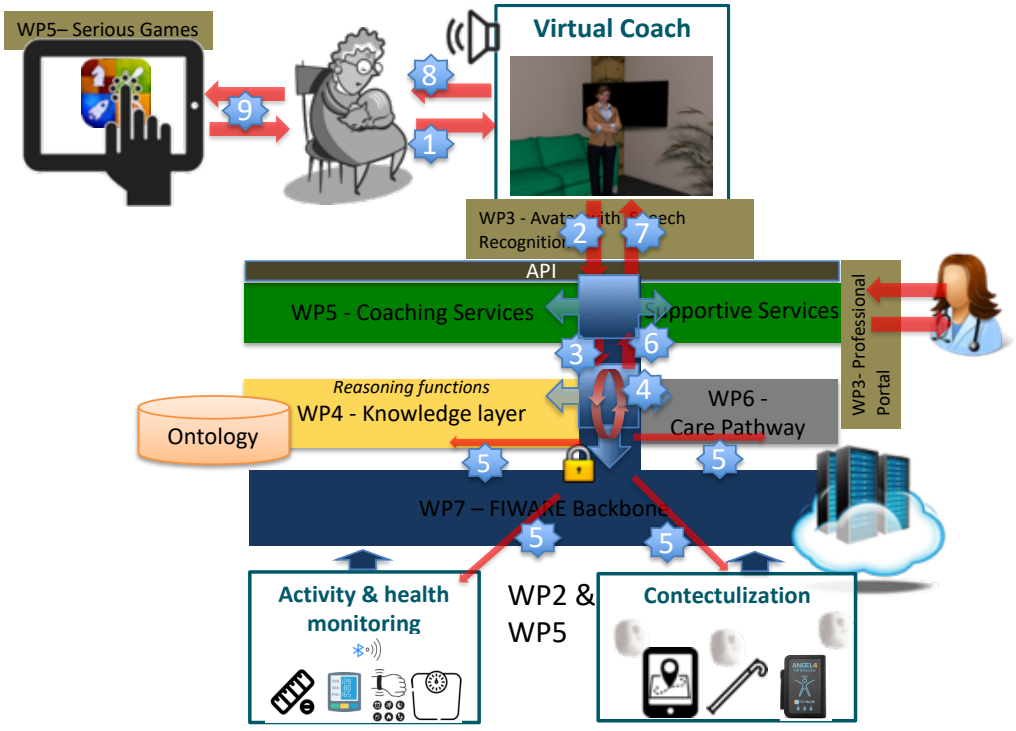

Figure 11: Simplified Schema of Main Components and their interaction

4.1 vCARE AS A SERVICE

vCare follows the **open platform approach as a good way to boost innovation** on the coaching scene, cheering up application developers, companies (e.g. Imaginary, Innovation Sprint), to integrate their solutions into vCare aiming to strengthen their offering. In this way, key characteristics of vCare, such as clinical pathways, intelligence, personalisation and the final UI adaptation and delivery can be part of 3rd party solutions through the vCare as a Service paradigm, which allows other systems to consume services from vCare, thus adding value to them. Similarly, vCare can also integrate with 3rd party solutions that offer complementary services and therefore, increase the applications that can offer. The vCare-as-a-Service interface will be demonstrated by integrating with the CloudCare2U platform (derived from eWALL project), to demonstrate how a 3rd party solution can consume vCare services. The services that will be consumed by CloudCare2U are related to the clinical pathways for a certain disease and the associated treatment strategies. CloudCare2U will be mapping these strategies with its pool of services and will synchronise them accordingly. We strongly believe that the vCare as a Service paradigm will add significant value and will support the project's exploitation strategy.

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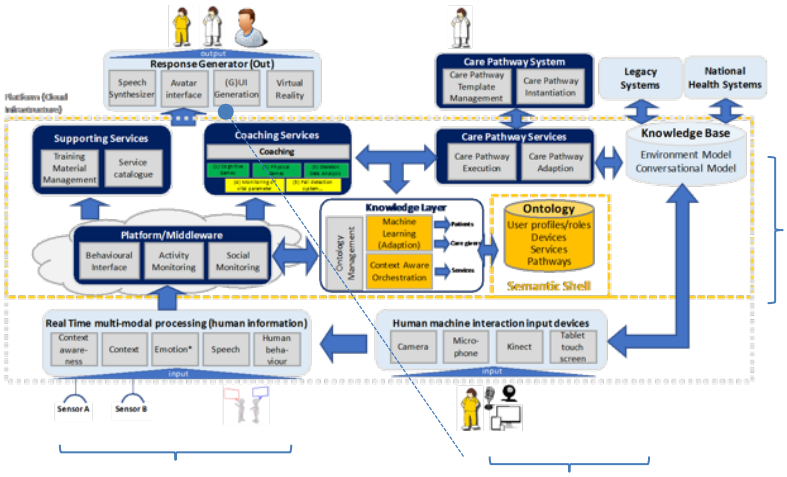
6 APPENDIX

6.1 FUNCTIONAL CONCEPT OF THE DOA AND RELATED COMPONENTS



(A) "central eHealth platform (conceptualized as Middleware) serves **central infrastructure services**. (GA, p. 19); "The infrastructure hosts common **supporting services, and special coaching services** that help to **preserve and improve the QoL of patients**. The coaching services provide exercises for **cognitive, and physical training as well as education materials** (fall prevention, life behaviour)."

(D) "Based on the inputs of the diverse devices and sensors, a real-time processing of the multi-modally gathered information will be conducted." (GA, p. 19)

(B) "It additionally provides interfaces to **integrate context** information delivered by sensors, or gained by the direct interaction between patient and the virtual coach." (GA, p .19)

(C) "Classical human-machine input devices like camera, or microphones are intended as well as advanced solutions like the Kinect that also allows tracking movements." (GA, p.19)

(E) "These services will be extended by a **care pathway services** and a **knowledge layer (reasoning service and ontology management)**." (GA, p. 20) [..] enable the possibility to personalize exercises, materials, and interactions with the patients.

Figure 12: Functional Concept of the DoA and related components

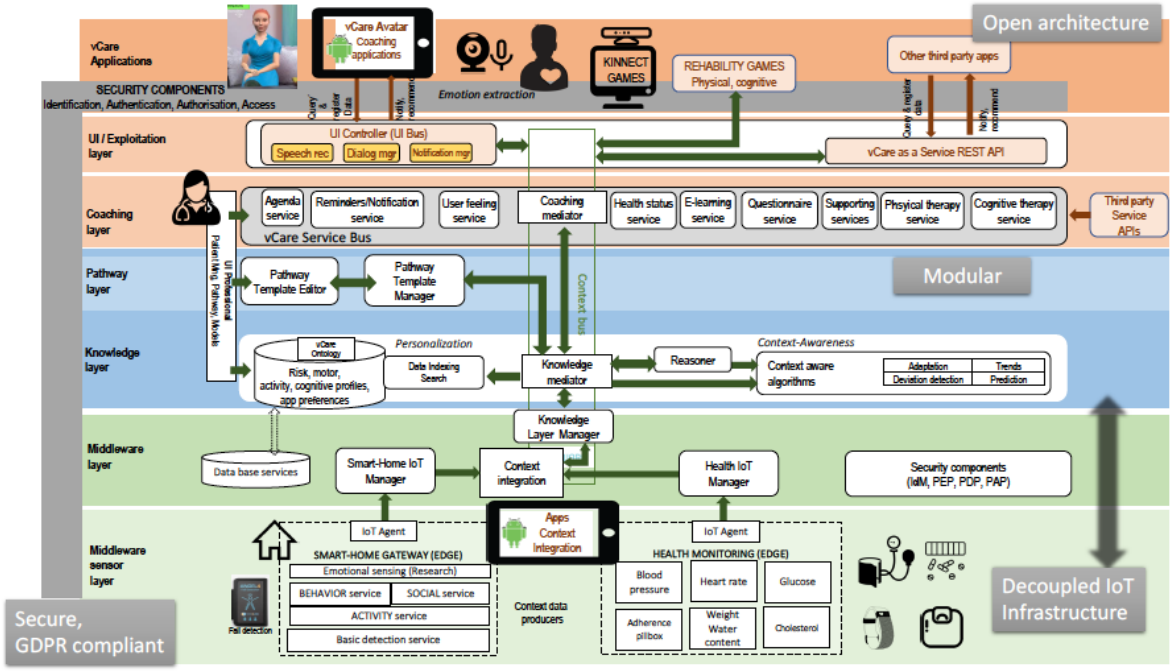


Figure 13: vCare architecture (see D7.3, as of 22.03.2019)