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Notes

This book is about project called aaion. It contains background information, description of problem and code reference as well.

This document contains different colors to highlight some type of content such as headings, hyperlinks and cross-links.

What is aaion?

Aaion is a human circadian management system to increase the user's performance and ensure better daily comfort. Aaion is open source software under Apache 2.0 license.

This system covers different levels of application: user level and server level. User level means the software that runs on a personal device such as mobile phone, smart watch, tablet, computer. Server level has a very different scope. It helps to manage multiple devices and create different shifts for large groups of people. Shift does not mean only a classic work shift system. With server level's management tool the administrators are able to create different day periods based on templates and monitorize the states of connected users'. Day periods can be longer or shorter than 24 hours, so it fits for the needs of a long time space travel. The whole system is based on the human circadian cycle. Our solution tries to fit the daily activities or time zone changes to the users circadian rhythm as best as possible.

The meaning of life from the view of our solution:

The meaning of life from the view of our solution is to choose the best **activities** during a day, that can **satisfy** the **needs** as well as possible **by changing** environmental and personal **factors**, while the whole process **fits** to the **circadian cycle and attributions** of the user. Or it can be said in a more economical way: The meaning of life is to create a daily schedule that grants the **lowest loss** as possible.

The problem

Technology and globalization get new challenges day by day for the human nerve system. We work at companies where colleagues live in other time zones on the other side of the Earth. Traveling across time zones is cheap. COVID-19 pandemic results in a new form of cooperation between people. Online meetings change flying that means there is no time for acclimatization to a new time zone. A lot of people live determined by two or more time zones. In home offices people jump from a state of sleep into work within seconds. These kinds of changes result in bad mood, fatigue, health issues and poor performance since there is a great challenge to fit the changes to the circadian rhythm. We categorize the problems into two classes. The first category connects to a daily life when the problems occur regularly and concern a lot of people, and the problems. The second part of problems affect a special and small group of people as astronauts, miners and underground workers. As it seems obvious, the slicing method is based on circadian rhythm. First group usually lives a normal daily routine, but the second group works and lives usually without a normal day-night cycle or a cycle that is longer or shorter, than 24 hours.

The problem of daily life

The problem of daily life contains three big parts:

1. shifting the daily routine from a time zone into an other one
2. managing a daily routine that fits into two different time zones at the same time
3. living and working based on a different time zone

The first case appears when people travel across time zones. Changing the daily routine is an easy task when talking about adjacent time zones, but it is much more complex when the time shift is above 6 hours or the travel occurs the sleep period during night time.

The second case appears in the daily routine of international companies that usually have offices around the world. Making a frequent meeting between two branch office is a

challenging situation. It can be more complicated when two people have to work together where they are living two different time zones.

The third case is when an employee, who real-time trades on a foreign country's stock exchange, should live based on the time zone where the stock exchange is.

The problem of astronauts

A non-conventional life can cover living in the space where the Sun rises multiple times in 24 hours or working underground where there is no sunlight at all. Living on a new planet or a moon could be a great challenge. Especially when the day-night cycle is longer or shorter, than 24 hours. Making a daily life and work-shift cycle is quite hard, that suits for astronauts' circadian rhythm and for MCC workers. The scenario is similar when we talking about underground workers instead of astronauts. The only difference that there is no chance to create a natural light-dark based cycle for underground workers if they stay weeks or months under the surface level without uplifting, since seeing the sunlight is impossible.

Competitors

There are a lot of software solutions that help to avoid fatigue or help to manage daily life to fit better to circadian rhythm. The best applications are based on circadian clock. There is a really huge gap in the market. It does not matter, how complex the solution is, the application works with fixed constants and formulas. The user can personalize only the big parts of day such as length of work or sleep. This method is good for a common user, but does not fit the needs of astronauts or business person whose colleagues are from very different time zones. There is only one person in the center of those apps. We think, it is time to focus on community of people such as coworkers, business partners, miners, astronauts and employees of big companies.

There are additional solutions to decrease the negative effect of jet lag. Beyond time-shift apps users are able to use sleep monitoring applications, meditation software, light sensors or noise generator.

Existing solutions

Timeshifter	+	science-based, popular, pre-travel adjustment
	-	missing support for unconventional non-Earth environments, paid
Jet Lag Rooster	+	easy-to-use, examples, web-based, supports melatonin, free
	-	supports only one use-case, missing scientific references
Entrain	+	science-based, circadian-based, travel support, free
	-	only for iOS, supports only one use-case, no melatonin support
Circadian	+	fatigue management, focus on industry, good for shiftworkers
	-	missing support for unconventional non-Earth environments, paid
Stop Jet Lag	+	personalized advice, instructions for lightning and eating
	-	supports only one use-case, paid
Uplift	+	science-based, guidance, promise no prior adjustment time
	-	supports only one use-case, acupressure is controversial, paid
myCircadianClock	+	science-based, eat-sleep-move support, photos for logging meals
	-	no support for time zone shifting
Sleep Cycle	+	full featured sleep tracking, wake-up timing, motion detection
	-	no time zone support, no melatonin support, no daytime scheduler
Sleep as Android	+	full featured sleep tracking, wake-up timing, motion detection
	-	no time zone support, no melatonin support, paid
Sling	+	employee scheduling, supports multiple locations, free
	-	no travel support, no support for circadian cycle of employees
MyNoise	+	noises make work during travel better, multiple use-cases
	-	sleep is better in a silent environment, no sleep tracking
Headspace	+	science-based, guidance, multiple use-cases
	-	only for meditation, meditation is regularly controversial, paid

and a lot more...

Solution

Aaion is a human circadian management system to increase the user's performance and ensure better daily comfort. Aaion is open source software under Apache 2.0 license.

The core of the concept was to create a software solution that is flexible and can run on different devices in very various environments. The existing solutions on the market cover only the main problems of common people, but they miss to provide widen and flexible solutions for rare problems. The whole software is deeply customizable. Each programming object works with default values that can be changed by user or administrator from server level.

The structure behind the code

The structure of our concept is independent from any programming language to provide a really flexible solution. We made an abstracted scheme that can be represented in any programming language. Aaion contains 6 different categories:

- Day
- Circadian rhythm
- Need
- Factor
- Activity
- Loss

Each category has unique attributions. The next section contains some explanation about them. When it is possible, we write the "programming name" between "[ ]" signs, for example: custom day [AlteredDay]

Day

However the base unit of time in SI metric system is second, people organize their own schedule by day and by hours. Day means the period of time during which the Earth makes a complete rotation around its axis. Besides this definition, people handle day as a time that equals with 24 hours. The approximation is good for the most of use-cases. We handle two different day types:

- “normal” day [Day]
- custom day [AlteredDay]

Day or normal day means the Earth-day that is 24 hours long and begins 00:00 (12 a.m.) and lasts 24:00 (12 p.m.). Custom day represents a day that can be shorter or longer than 24 hours. It occurs for example when we talk about other planets or environments under the surface or in space.

A day usually begins after midnight. The following details can be changed in our day construction:

- when the day begins
- the length of day
- which timezone is used

Circadian rhythm

Circadian rhythm is the natural wake-sleep cycle. The human circadian cycle on Earth is nearly 24 hours. The base unit of the circadian cycle is the circadian unit.

The following details can be changed in our circadian rhythm construction:

- when the cycle begins
- the length of cycle

Need

Need means the lack of something requisite in a specified time period. Need is the smallest unit that can be satisfied during one activity. A need has default values, but it can be changed. Need can handle functions to manage for example the depletion-level. The basic needs are:

- sleep
- work
- exercise
- any type of nutrition
- light
- noise
- temperature
- medication

The following details can be changed in our need construction:

- when the need occurs
- the value of need
- specified function
- type of need

It is important, that activity which can satisfy a special need is handled in the details of activity not in the details of need.

Factor

Factor is the actual level of any kind of need. There are 2 different types of factor based on the possibility of intervention to modify their actual or future level:

- personal factor
- environmental factor

Personal factors can be changed or modified by the user such as sleep, caffeine, nutrition. It is adjustable or measurable. Environmental factors can be set by the environment, we can only measure or calculate its actual level.

The following details can be changed in our factor construction:

- actual level of factor

Activity

Activity means any kind of action that is able to satisfy a need for example eating, sleeping, taking medication.

The following details can be changed in our activity construction:

- which need can be satisfied by that specific activity
- level of satisfaction, connected to a specific need
- when the activity begins
- the length of activity

Loss

Loss means the mathematical difference between the optimal, circadian-based schedule and the actual schedule. Loss punishes any kind of difference between the actual and the optimal routine. The punishment rate can be constant (1 for example), but it can be chosen freely. It is advised to use a function that calculate a non-linear loss, since some activities should be punished more based on how much time has passed. Loss can be calculated based on any needs or factors such as nutrition, light.

Attributions of user

Attributions are special settings for users that are able to help for customizing the software to get the better user experience. An attribute can be rule based or custom. Rule based attribute means that set a new value from a list results in a chain of automatic changes. For example, when a person change the type of bedtime from late person to morning person, the system will recalculate the sleeping parameters such as begin and end of sleep cycle. We plan to manage the following attributions at the moment:

- sleep
  - bedtime type
    - late person
    - morning person
    - mid person
    - custom
  - REM details
    - length of REM cycle
    - optimal number of REM cycle during sleep

Architecture

Aaion supports server and client-side solutions based on the needs of user. Client-side solution is good for unique user to manage a daily routine while server-side solutions fit for companies to manages daily routine or life of many users. The two different concepts exist simultaneously, but with different features. Server-side solutions cannot work without device or any kind of front-end from client-side.

Use-cases

- Earth-like problem
  - one time zone is involved
    - shift: travel
    - change: business (living in an other time zone)
- two time zones are involved
  - synchronize
    - equals
    - proportional
- non-Earth-like problem
  - new circadian cycle
    - shorten
    - stretchen
- 24h circadian cycle: synchronize

Sources

Our concept is based on very different sources or experiences. Some of sources were used to the concept and some of them can be use in a future if the active project will be successful. There is the usage of source after the source number between "[ ]" signs.

Source 01 [for limitations, use-cases and main frame of project; proof of concept were made by ideas based on this source]:
https://www.youtube.com/watch?v=wH2hL5Ua_m8

Source 02 [features; advises; concept and algorithm of the shifting of time zones based on the table about shifts of Orbit 1]:
https://www.nasa.gov/mission_pages/station/research/astronauts_improve_sleep

Source 03 [understanding of the problem; advises]:
https://www.nasa.gov/feature/ames/nasa-research-reveals-biological-clock-misalignment-effects-on-sleep-for-astronauts

Source 04 [understanding of the problem]:
NOTE: This source were removed from the resources section of Sleep Shift Scheduling Tool in NASA Space Apps Challenge 2020 during the hackathon
https://lsda.jsc.nasa.gov/Experiment/exper/1234

Source 05 [concept of needs (nutrition and time)]:
https://www.youtube.com/watch?v=AGR3FiEkBwA

Source 06 [understanding the problem of exercise, concept of needs (exercise and time)]:
https://www.youtube.com/watch?v=_ikouWcXhd0

Source 07 [time of space travel and jet lag; concept of needs (exercise, nutrition)]:
https://www.youtube.com/watch?v=ouDKD9G9jOE

Source 08 [concept of needs (nutrition)]:
https://www.nasa.gov/pdf/143163main_Space.Food.and.Nutrition.pdf

Source 09 [concept of needs (nutrition)]:
https://www.nasa.gov/sites/default/files/human-adaptation-to-spaceflight-the-role-of-nutrition.pdf

Source 10 [shifting circadian-cycle; formations of time shifting; future: aaion could be feeded by this data via API]:
https://techport.nasa.gov/view/23211

Source 11 [concept and algorithm of the shifting of time zones; negative effect of fatigue]:
https://techport.nasa.gov/view/23207

Source 12 [concept of needs (sleep)]:
https://techport.nasa.gov/view/23234

Source 13 [future only: aaion could be feeded by this data via API to measure factors better and set attributions of the user more precesily]:
https://techport.nasa.gov/view/96038

Source 14: [future only: aaion could be feeded by this data via API and aaion could take data to SmartSleep]:
https://techport.nasa.gov/view/96044

Source [inspiration only for the children living within ourselves; It is a great books for kids]:
https://www.nasa.gov/sites/default/files/space_nutrition_book.pdf

The following sources contains promising data, and they seem to be a good start for further data collecting, but we cannot investigate precisely due to time limitation of NASA Space Apps Challenge 2020 hackathon:

https://humanresearchroadmap.nasa.gov/Risks/risk.aspx?i=100

https://humanresearchroadmap.nasa.gov/Evidence/

https://humanresearchroadmap.nasa.gov/Evidence/reports/EvidenceBook.pdf

About Us

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We are two deep learning developers and data scientists. We work a lot of different field of AI developing, but our main objective is a computer vision in healthcare. Nowadays, most companies like to hire developers who are outsiders, who have other skills and education. We are lawyers who have jumped from law to programming and deep learning. We had a lo of opportunity from Facebook and Udacity. These companies maintain scholarship programs to get knowledge people around the world. We were two of them. Computer Vision Nanodegree or Deep Learning Nanodegree were supported by Facebook. Besides the knowledge, we got a lot of new viewpoint and the possibility to help others. We are thankful and during the COVID-19 epidemic, we are trying to get back something to the community and to the people around the Globe. Under these sign, we created the following projects.