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TREND OF INCREASED ADDRESSING OF HUMAN SENSES
- Focus on Sound -

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Abstract

One of the key results of Gendrich Altshuller's research is the definition of Trends of Engineering Systems Evolution (TESE). These Trends have proved their correctness over decades in the technical and nontechnical environment.

This paper suggests adding another viewpoint to the Trends by not only considering the development of technical system themselves in a technical environment, but by focusing on the interaction of a technical system with users and the thereof resulting requirements and development directions. It is an application of the Trend of system coordination.

The focus of Engineering System Evolution (TESE) is engineering systems. Nevertheless, engineering systems do not exist for their own purpose. Eventually they address human beings and serve them (the one way or the other).

Following this view the human being is the super system and even the target for the engineering system. The interaction between both is done by the senses of the human being. Following the trend of "transitioning to the super-system", engineering systems will include the human being or at least his senses.

Alexander Lyubomirskiy has shown in his research that there is a trend of "Coordination of images". This trend is focusing on only the visual sense of a human being. This study suggests expanding this approach to all human senses, auditory, kinesthetic, gustatory and olfactory. With this the complete human interface towards technology and the world is addressed.

This paper discusses the systematic approach to this evolution. It will display the human senses and relate to supplementary senses for animals. The way that technical systems are constructed to impact the senses and the evolution over time on how this is done with technical systems will be shown. Finally the usage of other trends (e.g. dynamization) to focus the impact of the technical system to the human senses will be discussed. The final point will be the development of technical systems to address several senses at the same time.

Keywords: TRIZ, Trend analysis, Trend of increased coordination, human senses.

Interactions

The world can be divided into two parts: animated organisms (human beings, animals, bacteria, etc.) and unanimated materials (earth, rocks, bricks, technical systems, etc.). Both parts co-exist in the same environment and influence each other.
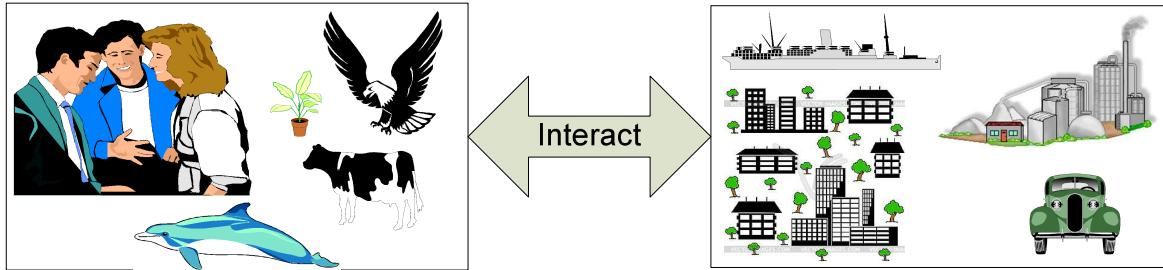
Interaction of the two parts on our planet: animated / unanimated materials
(CorelDRAW! Cliparts, 1993)

The interaction between both systems is based on the sensory / input channels of both parts. For unanimated parts this generally is the material surface (defined on the atomic level). Nevertheless, there are of course fields that may interact on deeper levels as well. For animated parts it is the sensors that are available. Human beings generally have 5 types of senses [1, 18]. Science is discussing if there are more, but for this research we focus on the confirmed ones:

- Seeing (visual) – distance sensing
- Hearing (acoustic) – distance sensing
- Sensing (touching), which may be separated into 3 separate aspects: touching, temperature, pain – nearby sensing
- Tasting (chemical) – nearby sensing
- Smelling (chemical) – nearby sensing

When expanding this analysis to other living units we find lots of supplementary sensors [2]:

- Bats use sonar
- Snakes use infrared light
- Bees and fishes can see UV radiation
- Fish use branch-line-organs for detection of water flow direction
- Electric eel can detect electrical fields
- Birds have sensors for magnetic fields and UV radiation
- Turtles detect the pH-value of water
- Spiders and scorpions detect vibrations
- etc.

Classification of interactions

Humans usually classify their sensoric input into the following simplified model:

Dislike	Neutral	Like
(Unpleasant	Neutral	Pleasant)
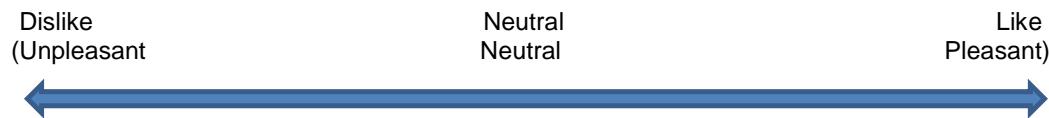
All of the information supplied by one or several of the senses is interpreted based on past experiences within a range from "like (pleasant)" to "dislike (unpleasant)".

With the decision "like (pleasant) / dislike (unpleasant)", living creatures direct their activities to the feeling layer. The other decision layer is the logical, cognitive decision process. It relies on countable and measureable arguments.

The most important trend is convergence to ideality. Technical systems aim at self-fulfillment of their functions. However technical systems do not exist on their own and for themselves. They are always, maybe via other technical systems, linked to human beings (living creatures). The final receiver of the functionality will be a person in the end.

In the real world an industry has been developed for the following purpose: marketing, design and advertising. In the last few years a discipline called neuro-marketing has evolved [3]. The idea is to use neuroscience to better understand customer psychology and behavior in the dislike (unpleasant) / like (pleasant) sense. Research has shown that human beings react on information they get through their senses with emotions and feelings. Emotions are neutral and represent a bodily response to inner and outer events. An example is starting to sweat when temperature is rising. Feelings reflect the conscious experience of being in a particular emotional state. This means that there can be emotional responses without feeling, but you cannot have feelings without accompanying emotion [3]. This leads to the relation of wanting and appreciation. An example is the choice of eating chocolate while on a diet. You feel the urge for a snack and the sugar boost, but consciously think it's a bad thing to do. Wanting is an unconscious aspect, appreciation is a conscious experience. And the conscious aspect is the one that can be influenced.

According to the above statements, a person allocates his environment and the information he obtains about it via his senses to categories dislike (unpleasant) – neutral – like (pleasant). Of course the binning is dependent on region, culture, experience and learning in life in general. Still the environmental perception will be categorized. Therefore the technical ideality a system is striving for has to be taken into consideration for the human binning process as well.

A particular branch, sensory neuromarketing, is emerging, focusing on how sensory inputs other than visual and hearing can influence decisions (like smell of fresh bred close to bakery). So also neuromarketing is developing in the direction of involving more senses contemporarily.

There are studies regarding Multisensory Integration, which describes a process by which information from different sensory systems is combined to influence perception, decisions, and overt behavior.

Hyposthesis

TESE concentrates on the technical evolution of components, which reflects the logical side of the decision making process. The first hypothesis is that components too evolve towards emotional ideality in terms of generating a "like" (pleasant) feeling or, in case of warning, a "dislike" (unpleasant) feeling. The second hypothesis is that components evolve from addressing only one sense towards addressing multiple senses. This is another view of the Trend of system coordination.

Hypothesis 1 focusses on improving the functionality of the component. Relating this to the S-curve development, this strategy may be used in the 1st and 2nd stage.

Hypothesis 2 focusses on intensifying the number of senses addressed. Here the technical functionality of the component is more or less ideal and there is a shift towards the emotional impact. This is applicable to components in the 3rd and 4th stage of the S-curve.

The defined hypothesis shows trends of the evolution of the components per se. Of course a manipulation by conscious combination of senses addressed or by inverting an unpleasant feeling to a pleasant one or vice versa is possible and even probable in business applications.

These methods of applying of a trend to influence conscious and unconscious senses will be discussed later in this paper.
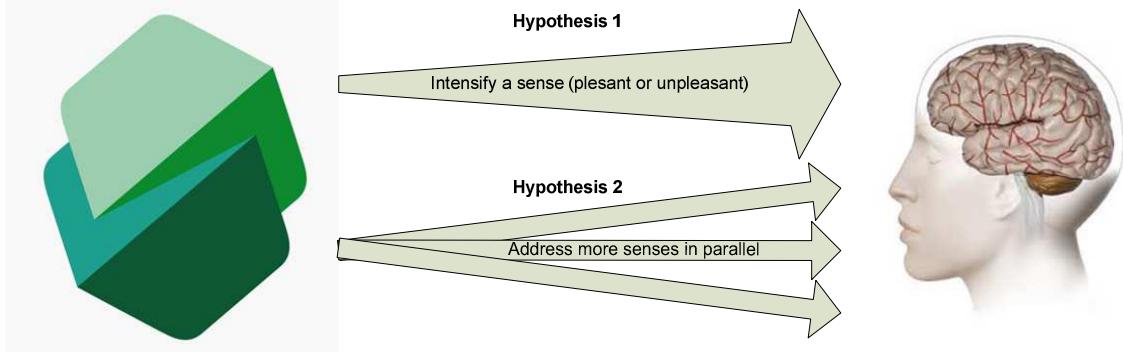

Observations

The hypothesis that components / systems evolve towards emotional ideality is hard to prove as there is no "old emotion" that can be conserved in an objective way. Therefore as a first indicator we will look at the different human senses and how they affect our brain / thinking and how they were stimulated in the past.

Principle function of our brain

The human sensors are connected to our brain where data evaluation is performed. The principle set-up of our brain functionality is shown in the following figure. It is basically divided into 2 parts: left and right. The right side is designed for our more creative, chaotic and unconscious capabilities. The left side represents our logic, number-oriented, systematic and conscious capabilities. Both sides are connected and interact.
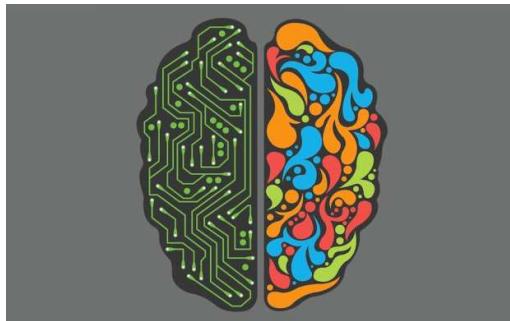
Brain functionalities: left side "logic", right side "creativity"

Neuroscience has shown that the right side as the unconscious side is operating ~ 100 times faster in data processing than the left side of our brain (the conscious part) [4]. This fast operation generates the "guts feeling" very fast but lacks the reasoning where this feeling is coming from. The left side needs much more time to generate the same result, but in this case the process of reaching the result is conscious.

Our sensors are attached with some preference to the different sides of the brain. Our distance senses (seeing, hearing) are related more to the left side (conscious, "logic" part) and the senses of sensing, tasting and smelling while the near senses are related more the right side (unconscious). This has an evolutionary background. If a danger was registered nearby by our senses an intermediate reaction was needed. There was no time for an extensive evaluation by

our slow left brain side. Our distance senses offered more time for a reaction and are therefore connected to the left side for a conscious and learning experience.

Psychology has shown that usually a person has a preferred side, dominating his characteristics and behavior [4]. According to the Trend of Engineering System Evolution (TESE) the system "brain" tends to bring both sides together as an equivalent system [3]. This is especially true for today's time, where only very little sudden danger occurs in our life (unless you cross a traffic road with closed eyes).

Main Human Sense Seeing (visual)

Looking back into history people were not very much interested in "how good something looks" except for religious artefacts and paintings. Churches, mosques, temples were constructed to be higher, brighter, more valuable, prestigious, etc. Evolution always went in the direction of "more impressing". With industrialization the design of components got more and more important besides the pure functionality. Today a product has to be designed, even in an industrial environment. At least colors have to look appealing for a component and this is getting more and more a decision criteria for users and customers. Looking at a car advertisement in the 1960s was all about technical features: engine size, speed, acceleration, volume of the trunk, etc. Today it is about the feeling:

1960   2014

Car advertisement past and today (magazine.volkswagen.de; bmwusa.com)

Another area is fashion. The functionality of clothes today is taken for granted. It distinguishes from the felt appearance: Does it "look good"? Since the functional evolution, fashion has concentrated on feelings. Usually the visual sense is more related to the left sector of the brain and thus refers more to conscious influence. Information is taken and consciously analyzed for the decision of pleasant / unpleasant [1].

Another aspect is the function „inform people". People wearing luxury objects inform other people on the economical / social status of the owner or belonging to a certain group or subculture.

Also Apple works with their products a lot on visual for the same reasons and in addition, the visual interface is perceived as more intuitive since the brain is a strong visualizer.

Main Human Sense Hearing (auditory)

The evolution of sound found its direction in music. Components are allocated with sound that makes you feel good and generates a pleasant feeling. You can see this with cars: the sound of an engine has to correspond to its perception of delivering power and speed. The German Railway made a survey to find out in which train people feel safest. It was in trains with a dedicated locomotive that made a lot of sonorous noise (from the cooling fans) – the feeling of power – instead of a bee's sound from distributed drives. Sounds are designed today to generate different feeling: sirens for emergency vehicles to generate awareness (using the unpleasant aspect of these sounds – loudness and yelling type), background music in shops to open the emotional channel of customers (and retain them inside), etc. Usually the auditory sense, too, is more related to the left sector of the brain and thus refers more to conscious influence. Information is taken and consciously analyzed for the decision of pleasant / unpleasant [1]. So the two dominating senses (seeing and hearing) are related to our conscious perception.

Main Human Sense Sensing (kinesthetic)

One of the tools we are mostly using unconsciously is sensing. When judging a component we often take it into hands, touch it, feel the surface, its density, humidity, weight, etc. This can mostly be observed in food shops. We take the product into our hands. We look at it and touch the packaging to get a feeling. This is essential for the final purchase decision. Usually the sensing sense is more related to the left sector of the brain and thus refers more to the unconscious influence. Information is processed within milliseconds and generates a response of pleasant / unpleasant [1]. Touching something too hot or hurting is a direct threat to our body. And this threat is very near. Therefore our body produces an unconscious direct reaction for protection purposes. Visual and auditory senses are more distance related and therefore can afford to bypass the conscious mind, which takes longer for data processing, but allows more fine-tuned response.

Touching, feeling the product with our sensing sensor (sueddeutsche.de)

Main Human Sense Tasting (gustatory)

Babies and kids test their environment by trying out how it tastes: can it be "eaten". Food as the essential product to be tasted has also undergone a development. In former time food was seen as energy provider with only little variation from day to day. Today taste is designed into products. Flavor enhancers are used to generate a certain taste. The best examples are burger chains where the food offered tastes the same all over the world (convenient food). Usually the sensing sense is more related to the left sector of the brain and thus refers more to unconscious influence. This is due to the fact that bad food can be life-threatening and is

identified by the taste. The reaction to bad food has to be immediate and therefore is unconscious.

Kids test their components by tasting (mytoys.de)

Main Human Sense Smelling (olfactory)

Smell has the most direct impact on the brain [1]. In contrast to the other senses the brain allocates a feeling to smelling right away. This feeling without the detour via emotions is based on the history of experience of a person. So it can be that a smell that somebody likes a lot and considers pleasant (like) can be ugly for another person and generate a dislike (unpleasant) feeling.

Allocation of smell to a product – emotionally (weingeruch.de)

Smelling works in a similar way as tasting. It has a direct impact and therefore is unconscious as well.

Evolution Directions of the Hearing / acoustic / auditory Sense

This chapter will focus just on the acoustic sense as example. I will lay out how the sense itself can be influenced and how the influence can be intensified. Examples in nature and technology will be displayed.

Alexander Lyubomirskiy from Gen3Partners conducted deep research on trend for "coordination of images" which reflects a set of measures and principles to increase or decrease visibility in general. This is in very close relation to the major sense of the human being: "seeing (visual)". One can leverage this methodology to hearing (auditory), sensing (kinesthetic), tasting (gustatory) and smelling (olfactory), which will be done in the next steps. At the end a combination of the coordination of the senses will summarize the trend to satisfy human senses.
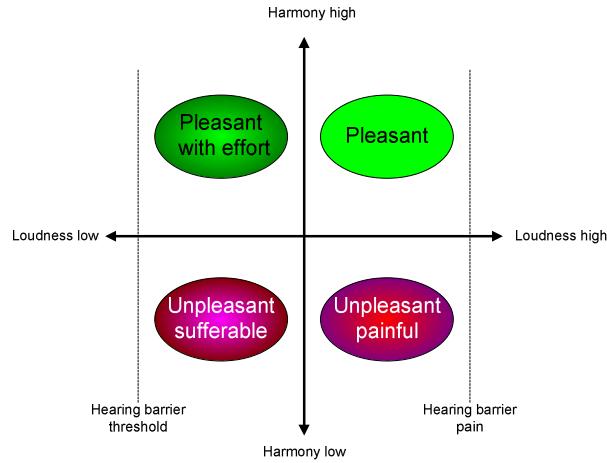
Two basic parameters for hearing

Hearing or, more generalized, sound detection is a sense that is allocated to the ears. It can be rated by two parameters: Loudness and Harmony
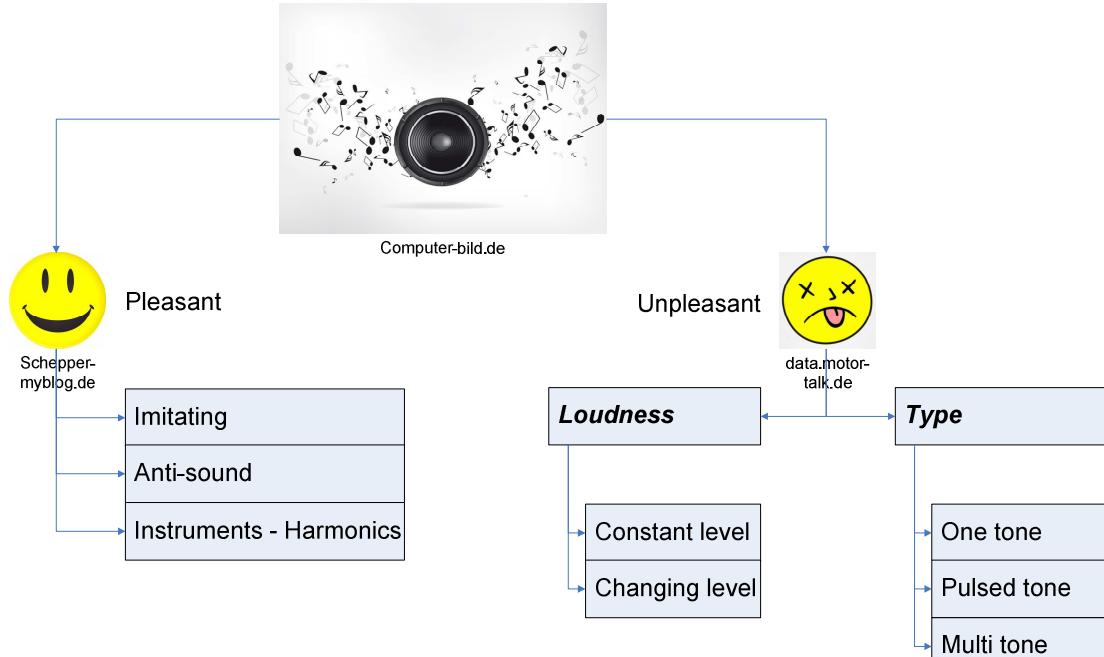
Structuring of sounds

Sound in its basic form is a sine wave. With a single wave at a defined frequency the loudness can be experienced. It starts at the hearing threshold and stops at the pain barrier where the loudness starts to hurt.

Starting from the basics of sound (loudness and harmony), they can develop into different directions. The major separation, in relation to the coordination of images, can be done by separating pleasant and unpleasant sounds.

In real life a sound is always composed of a superposition of sine wave. Here human beings have an affinity to a composition of the sound. It has to follow mathematical rules in order to express harmony and to generate a "good feeling". In music, harmony is the use of simultaneous pitches (tones, notes), or chords. The study of harmony involves chords and

their construction and chord progressions and the principles of connection that govern them. Harmony is often said to refer to the "vertical" aspect of music, as distinguished from melodic line, or the "horizontal" aspect. Harmony usually generates a "comfortable feeling" and disharmony an "uncomfortable feeling". A harmonic sound with the right loudness is pleasant. If it is too silent it is pleasant but with effort as one has to concentrate to get it. A disharmonic sound at low loudness is unpleasant but bearable. If it is too loud it becomes a painful experience.

Pleasant sounds

In the category of pleasant sound we find imitating sound, anti-sound and instruments.

Imitating sounds

Imitating sound is often found in nature where e.g. one type of animal copies the sound of another species in order to warn enemies although they do not possess the features of the original species. Examples of imitation are:

- The starling imitates the oriole. Orioles are birds that stay mainly on their own. A starling therefore imitates its sound in order to chase away the rival when it comes to secure bird's nest area.
- The black earth colubrid. She imitates the sound of a rattlesnake to protect herself.
- A ventriloquist imitates the voice of another person.
- The real sound of an airplane is imitated in a remote-control model.
- Playback in music shows is another way of imitation.

In technical system imitation is used e.g. for burglar protection. Electronic devices imitate the sound of dogs to prevent intrusion into homes.

Anti-sound

Anti-sound or sound cancellation is used in technology to dampen the loudness of a sound. The principle is to generate the same sound artificially but with a phase shift of 180°. By this the waves extinguish each other. The same principle can be found with Bolus at ships. There it is not to extinguish sound but water waves in order to reduce energy consumption for ships (reduction of deformation of the water surface).

Instruments

A special effect of sound can be achieved by not only playing the base frequency of a tone, but by adding harmonics to it. This is what happens when playing a tone on an instrument (not necessarily an electronic piano that can play only the base wave as well). By this e.g. the tone takes on different colors. With different instruments playing together the super-positioning principle applies: As for an instrument the base tone is superposed with harmonics, the instruments themselves behave like harmonics.

Harmonics are a means to also express as well certain moods (like joy, melancholy, etc.) that can be used to bring people into a certain emotional condition in order to achieve desired reactions.

Unpleasant sounds

In the category of unpleasant sounds two parameters can be changed: loudness and type of signal. Generally loudness and type of signal are combined in order to achieve the attention of a person. In communication when a partner does not react, the typical reaction is to raise loudness. By this attention shall be generated. If this does not work the sound is alternated in its frequency as well. One can see this especially with kids when they cannot obtain attention from their parents.

Another field of application of unpleasant sounds is warning: fire, air-raid warning, police and emergency vehicles. In these cases the unpleasant (harmful) sounds are turned into something useful: gaining attention.

Loudness

Loudness can be set at a constant, static level or at changing levels. Human beings usually tend to adapt to constant levels as the senses are mainly reacting on changes (HNO Basiswissen). In order to generate more attention the loudness can be raised and/or lowered in steps or continuously. Good examples of this are emergency horns:

- Single-tone horn.
- Sinusoidal changing air raid warming.
- Tornado Chicago warning.

Type

Besides the loudness the type of signal can be changed. As differentiation one, several tones and pulsed tones can be used to generate an unpleasant feeling and thus create awareness. The best examples for this are fire warning devices that use trapezoidal tone changes and the sirens of police cars. Dependent of the country they have two tones (e.g. Germany), pulsed tones (e.g. United Kingdom) or a combination of loudness change, multi tones and pulsed tones (e.g. United States).

Future Outlook on application of Sounds

In the chapter before the development of sounds has been demonstrated according to its parameters. Examples of technical realizations were shown. The focus of the evaluation was on sound only to demonstrate the procedure of examination.

As a human being has at least five sense (seeing, hearing, smelling, toughing and tasting) the trend is to incorporate at the end all of them. The procedure will be:

- Add another sense
- Dynamize the sense
- etc.

As one example the development of cinema movies shall be shown.

Development of cinema movies over time
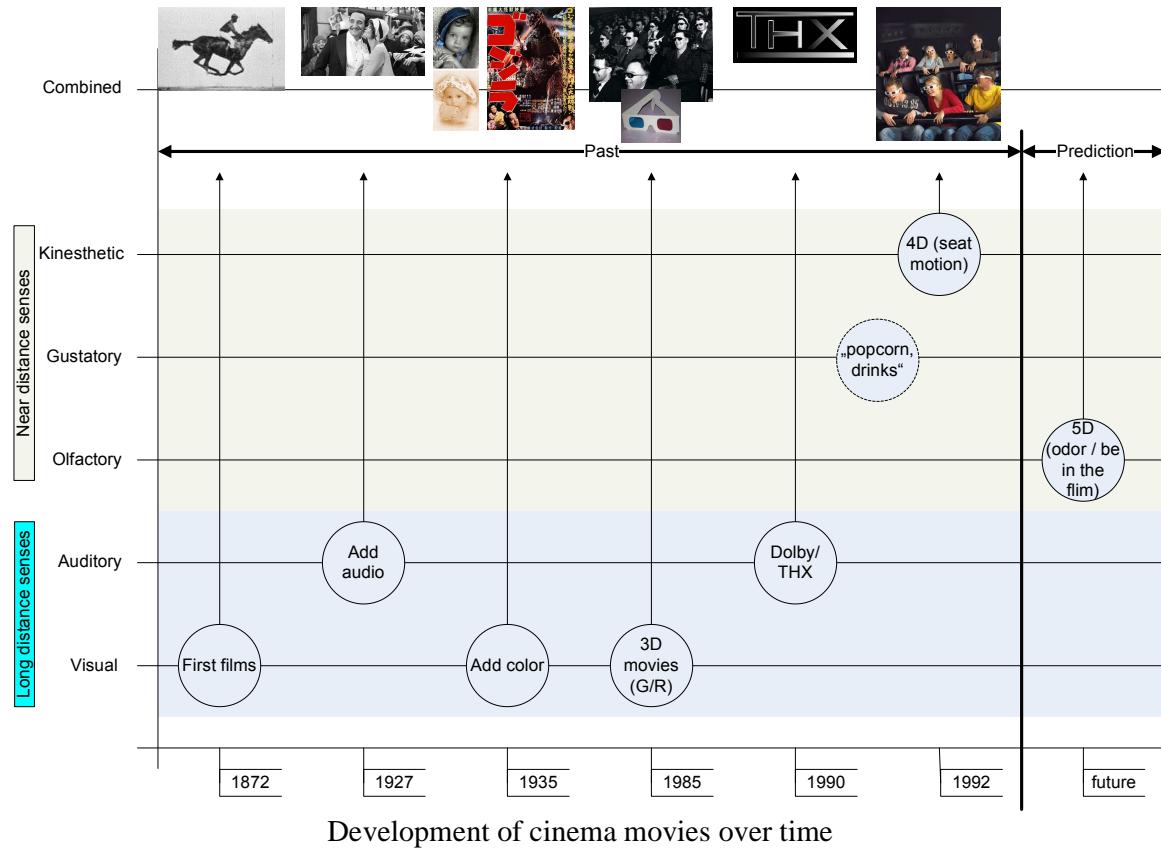
Around 1872 first films (visual) are made. They are black and white, no sounds and the quality was poor. Around 1927 sounds (audio) were added and 5 years later (1935) first color films (visual) were available. 1985 3D movies were developed; but it took 15 years until 2000 to develop a better technology (polarized light instead of red/green separation) to make them accepted (visual). Around 1990 the sound was improved by moving from stereo to surround sound with noise suppression (audio). Around 1992 the first 4D movie including air steams or movable seats came (kinesthetic) on the market. In parallel selling sweets and drinks came en vogue in cinemas (gustatory), although this doesn't have directly to do with the movie itself.

The prediction is that odor will be added to movies if corresponding ventilation systems will be available. Or chewing gums with different tastes, which correspond to the meals that are served in a movie, will be available. Another path are movies where you can interact with the plot (e.g. seeing it from different perspectives).

The auditory sense itself evolves in this example in a dynamic way: from just sound to THX. So we see the well-known trends being the basis for the umbrella trend of increased addressing of all human senses.

As development of police and their equipment is another example:
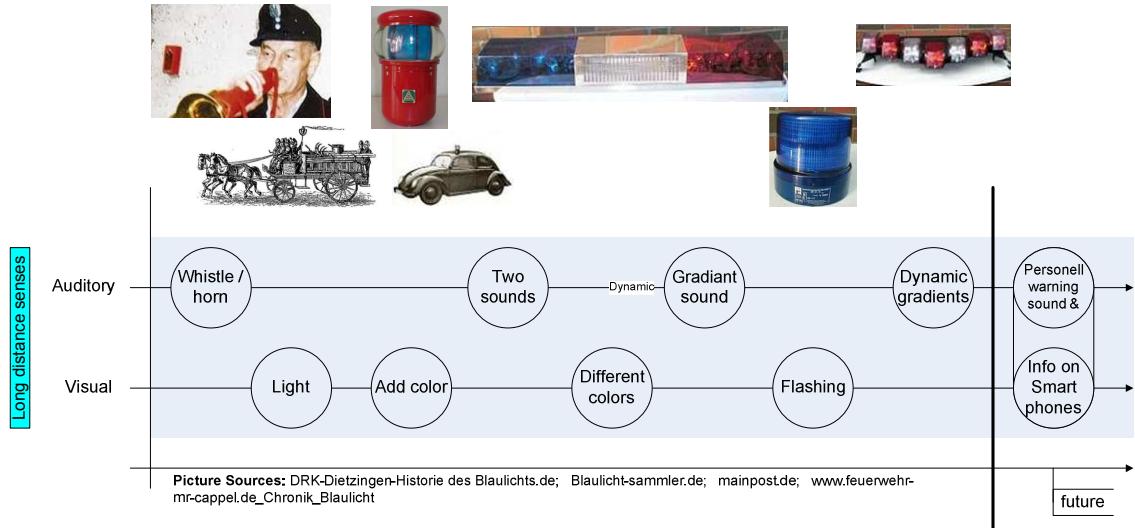
Development of police sound / light system over time

Police cars started with torch and whistles / horns. The light was turned electric and blue. Then the light was dynamized to flashing. Whistling was replaced by sound. The next step was to dynamize the sound to 2-frequency signals. Next step was to dynamize the lights with different colors (blue and red, later yellow). And the sounds were dynamized: Different loudness, different frequencies, pulsed, etc. The future might be that everybody nearby a police car gets a personalized warning sound and information on his smart phone.

Conclusiones

In the paper it was described that technical systems evolve towards addressing more and more senses of a human being. The most obvious ones are the long distance senses visual and hearing. Their development has been displayed in the paper. This trend is as well confirmed by research in neuroscience. The biological foundations of multisensory integration and its effect on human being's life and decision-making processes points in the same direction. Human-made artifacts in their evolution as engineering systems reflect the tendency to achieve an increasing involvement of the various human senses. This paper focused on hearing although similar principles are applicable be smelling, touching, tasting. This discussion will be part of another paper.

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