Analysis of New Lift Typology with Visual Stimulation of Passengers

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Abstract. For years, lift cars were more like closed transportation boxes than elements of architectural experience. The lack of visual stimulation encountered in a conventional lift became an awkward interruption to the otherwise enriching experience offered by the architecture of public buildings. A glass-walled lift car provides an ideal solution to that disruption, but is not feasible in most instances and often entails extra costs. As a result, the lift level indicator, supplemented in some advanced cases with cartoons, has become the standard tool used to inform passengers of their current position. A lifelike virtual lift window system, designed to transform passenger experience, was released four years ago and gradually found a niche in sophisticated lifts for upscale buildings. The technology relies on the precise calculation of every pixel and offers a real-time picture of the outside view combined with augmented reality and contextual information. Modern trends of visualization employed in lift cars, including virtual windows, vary in degrees of image quality, positioning accuracy, and lag. In times when 'architecture at its best is coming up with something that is pure fiction', we have in our possession a tool that is already embedded in the vertical transportation cabin. There is a sound advertising potential, more humanized typology of lift design, and almost universal navigation tool for visitors of public buildings. Further prospects of employing that technology in forthcoming multidimensional lifts as well as in conventional lifts are shown in terms of technical feasibility, costs and outcome.

1 INTRODUCTION

Thanks to recent dramatic progress in design and manufacturing of widescreen displays, we now see widespread implementation of said screens in lift cars. We shall refer to these large flat screens installed inside elevator cars as 'virtual windows'[1]. This type of installation enables visual stimulation of passengers by offering entertainment content, advertisement videos, emergency announcements, news feed and, last but not the least, navigation cues.

Well-known showcase boxes, which still may be found in some hotel lifts, became the early predecessors of virtual windows, while small-size displays built into the operating panels were their immediate precursors.

2 LIFTS WITH VISUAL STIMULATION OF PASSENGERS

As mentioned above, virtual windows have been installed numerous times, and are rapidly spreading across the globe. Fascinating new installations have recently appeared in the UK, US, EU, China, Republic of Korea, Japan, Malaysia and many other countries.

We believe that numerous examples of virtual window-equipped lift cars constitute a new, separate

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[1] Please note, that there is an alternative term *'lifteye'*, introduced by AFAG Messen und Ausstellungen GmbH for the category of products, related to *real time* lift virtual windows [1, 2]

lift typology where the visual stimulation of passengers is a primary distinction.

To compare known cases of virtual windows, see this 3-dimensional diagram (Fig. 1) with the following axes: 'Actual Environment reflection degree' (x), 'Adjustment to the Height Position' (representing adjustment of the viewer or lift car height position to the performed perspective) (y), and 'Time Lag 1/τ' (z). Someone may find out there various cases from still pattern/picture on lift car wall or just painted one to animated cartoon, fictional environment displayed on walls (or ceiling) and up to live, real time virtual window wall / car door.

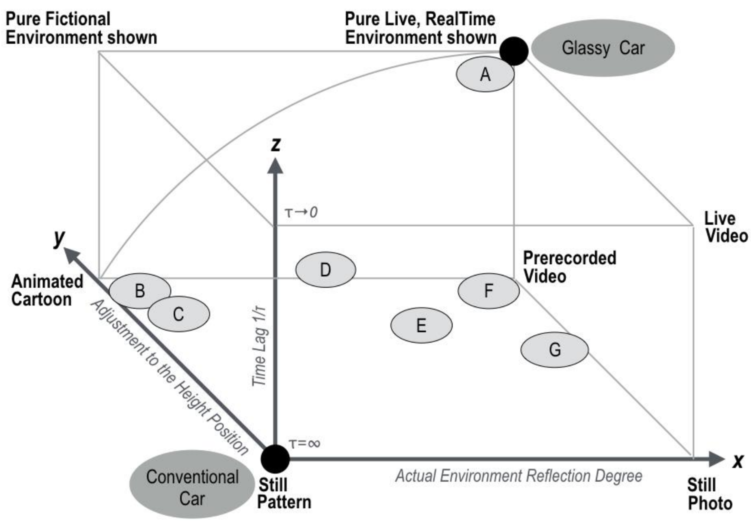

Figure 1. 'Virtual Window Box': 3-dimensional diagram of virtual window utilization cases in lift car.

Prerecorded and fictional movies and mixed cases, released in The Shard, London (C); 1WTC Tower, New York City (D); Lotte World Tower, Seoul (E); Petronas Towers, Kuala Lumpur (F); Tour Montparnasse, Paris (G) [3] and real time virtual window, Augsburg and London (A)

Please note that the location of the Conventional Car with non-transparent walls ('Still Pattern') and the panoramic 'Glassy Car' can be easily found on the diagram - see the gray ovals. The glassy car represents the case, in which a lift passenger can view the actual environment with a correct perspective and in real time ($\tau = 0$). The visual stimulation in the glassy car seems almost perfect.

The obvious disadvantage of panoramic lifts is their limited feasibility due to structural issues and thus relatively high associated costs. Those limitations force the developers to opt for video walls and ceilings in lift cars (Fig. 2, 3) paired with non-real-time content.

The absolute majority of known virtual windows offer zero to little reflection of the outside reality. On the chart, these installations remain close to the x-axis. In most cases, the performance of those virtual windows depends on the actual position of the car (y-axis); therefore, all of these cases tend to belong the horizontal ($\tau = \infty$) surface of the diagram. In other words, the content of those virtual windows (or ceilings) does not reflect the outside world.

We believe that those virtual windows ('B' to 'G') are adequate for one-time visitors, but not for residents. It is hard to believe that someone will enjoy the same content when viewed over and over again. That was our primary challenge.

Figure 2. A case of *fictional content* virtual window installation, New York City.

Nine HD screens installed in lift car (3 displays on each car wall). Content shown corresponds to actual position of lift car. Released in May 2015.

Figure 3. A case of *fictional content* virtual window installation, London.

9 flat displays installed in the lift car ceiling [4]

The natural answer is to offer a live, real-time picture ($\tau \rightarrow 0$). One possible solution is described in US patent 9,571,798 (Fig. 4). The proposed device renders a real-time, live image, with the correct height perspective. A working prototype of that device, with one wide HD display was introduced in October 2013 in Augsburg, Germany (Fig. 5) [5, 6]. To provide the real-time feed, only two HD cameras were utilized. They were mounted on the outer wall of the building with the lift as shown.

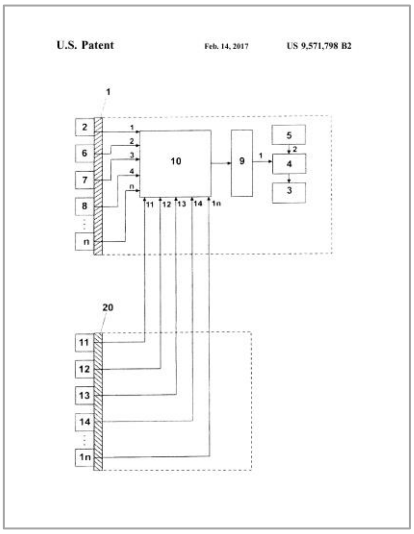

Figure 4. Device for displaying the situation outside a building with a lift.
US Patent 9,571,798

1- outer wall of building with lift; 2, … n - cameras; 5 - precise lift car height sensor; 3 - display, installed in lift car; 20 - outer wall of distant building.

Figure 5. Case of live, real time virtual window: one of two HD cameras mounted on building façade (left) and HD LED display mounted on rear wall of lift (right). Augsburg, 2013

When a real-time feed becomes available from cameras set in other locations, it becomes possible to switch the image to that feed. This feature might be attractive for hotel chain operators, office building of large international corporations and in some other cases.

On the diagram (Fig. 1), a live, real-time virtual window is marked 'A'. It is very close to the 'Glassy Car' point. The proximity of 'A' to 'Glassy Car' is limited by the time it takes to process the real-time image feed, and may be further affected by the lag in the communication channel between the main building and the distance source.

The basic requirement for the software is to exclude delays in computing the vertical position, especially during accelerations and decelerations, in order to prevent motion sickness.

The ability to render virtual window pictures in high resolution is paramount. The feedback from the 2013 Augsburg installation confirmed that passengers, being so close to the walls, didn't find Full HD / 1080p (1920x1080) displays comfortable due to the relatively large size of the display pixels.

Ultra-high-definition, or UHD-1 / 2160p (3840x2160) displays are preferable in this case. The overall cost of the system is higher due to the higher price of UHD cameras and higher computational requirements (both hardware and software).

The temporary installation of UHD real-time virtual window (Fig. 6, 7) in London (May 2015) became a trial of UHD cameras, software and display as a set [7].

Figure 6. A case of *real time* virtual window installation, London.

The temporary installation of *real time* virtual window in car lift with an outside view of the building (left) and from distant location (right). The displayed view corresponds to the actual position of the lift car, as measured by height sensor. Perspective is smoothly altered as the lift ascends or descends, giving an entirely realistic sense of place and time for passengers.

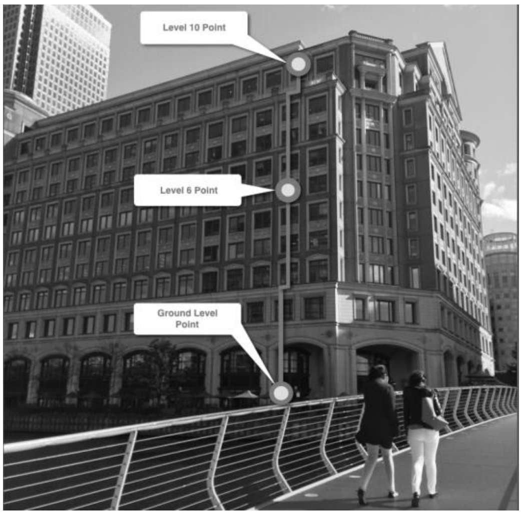

Figure 7. A case of *real time* virtual window installation, London.

Three cameras are mounted (as shown) along a vertical line on the outer wall of the building to provide an ultra-high-definition real time feed for display in the lift car.

The most important specifications of the virtual window are: the thickness of the display, its weight, its power consumption and heat emission, and its ability to withstand impacts and scratches. The latest generation OLED (organic light emitting diode) displays come as thin as 2.57 mm [8], and the weight of the assembly has reduced dramatically as well. These improvements provide more flexibility to cabin designers. Ion exchange-hardened glass has become an industry standard over recent years, and this type of glass finally delivers scratch and crack resistance sufficient for virtual windows. In certain specific cases, an additional translucent protective layer may be required to protect displays in high-traffic areas.

One specific shape of a real-time virtual window is a lift car door (Fig. 8). It is equipped with four wide UHD displays [9]. The door is declared compatible with EN81-20 and suitable for new lifts as well as for replacement of car doors of any brand.

Figure 8. A case of *real time* virtual window as an integral part of car door.

A working prototype of the door with four UHD displays was inaugurated in Augsburg, Germany in October 2015

We believe that a real-time virtual window car door is a good solution for lifts where passengers ride frequently or even daily. It is well known that most of them tend to face the car door, rather than walls, during their trips. This is true even for panoramic lifts.

3 CONSTRAINS

We've learned that privacy issues in many countries may prevent installation of real-time virtual windows in any form, and therefore specific measures as blurring of human faces and car license plates should be taken.

Data channel capacity limitations between the lift and a distant location, from where the real-time feed has to be transmitted, may dramatically reduce the overall performance of real-time virtual windows. Some quasi-real-time solutions are known and may be adequately employed.

4 FURTHER PROSPECTS

We believe that virtual windows and real-time image feeds will prove to be a prime navigation tool for future lifts with linear motors which move people vertically and horizontally.

What will the virtual windows in lifts stream tomorrow? Pure fiction, real-time, or some mixture of both - we'll have to wait and see. In any case, the new lift typology is already becoming an essential part of the architecture, which ‘at its best is coming up with something that is pure fiction’ [10].

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BIOGRAPHICAL DETAILS

Aleskey Gorilovsky has been CEO of LiftEye Ltd since 2013. An electromechanical engineer by training then specialized in precise torque drives and has extended experience in academic field. He also studied in LSE and got EMBA from SSE. Entered lift business in 1993. He set up his own lift company in 1997 and rapidly run it to the leading position in upscale segment in the territory providing full service for world famous hotel chain operators, retail and offices. He has been granted with patents for tall building lifts.

Dmitry Gorilovsky has been Chief Innovation Officer of LiftEye Ltd since 2013. Dmitry graduated from ITMO University of St. Petersburg. He is a product and solutions innovator with extensive experience in the mobile and IT industry and is currently focused on enabling complex technologies with simple human interfaces. Dmitry has been awarded numerous patents, some of which are for tall building lifts.