INTRODUCTION

Human crowd convergence theory holds that crowd behaviour is not a product of the crowd itself, but is carried into the crowd by particular individuals. Thus, crowds amount to a convergence of like-minded individuals. In other words, while contagion theory states that crowds cause people to act in a certain way, convergence theory says the opposite: that people who wish to act in a certain way come together to form crowds. An example of convergence theory states that there is no homogeneous activity within a repetitive practice, sometimes observed when an immigrant population becomes common in a previously homogeneous area, and members of the existing community (apparently spontaneously) band together to threaten those trying to move into their neighbourhoods. In such cases, convergence theorists contend, the crowd itself does not generate racial hatred or violence; rather, the hostility has been simmering for some time among many local people. A crowd then arises from convergence of people who oppose the presence of these neighbours. Convergence theory claims that crowd behavior as such is not irrational; rather, people in crowds express existing beliefs and values so that the mob reaction is the rational product of widespread popular feeling.

Simultaneously with digital tools (such as programming) development, interest to crowds simulations start growing. One of the most complex and interesting crowd behaviours is human crowd behaviour.

The usage and implementation of crowd system was enabled by Craig Reynolds in 1986 when he first established the common most basic rules of crowds as mentioned further in the paper. Ever since the complexity and intriguing emergent behaviour of crowds – of whatever nature – has been found useful in many domains such as biology, economics, structural engineering, graphic design, urbanism and of course architecture, since it is based on a self adjusting system where n-number of individuals perform an action as a crowd, based on local and diverse conditions.

Recent research on crowd behaviour, more specific on human behaviour has been conducted by Guy Theraulaz (Research Center on Animal Cognition, CRCA, University of Toulouse/CNRS), in a straight collaboration with Dirk Helbing of the Swiss Federal Institute of Technology in Zürich. Their research showed that 50 to 70% of pedestrians do not move alone but in small groups of 2 to 4 people.

The well known research office Kokkugia (Ronald Snooks & Robert Stuart-Smith) has been developing theories and examples of how crowd based design can be interpreted and used by architects. In numerous projects – whether competitions or commissions – they have been implementing the crowd as a tool for different scales and purposes, such as swarm urbanism, structural compositions. Through their research they proved the utility of this design method as not merely a shape forming method but as an intelligent way of dealing with both material matters and spatial distribution.

The issue of crowd based design is highly discussed and therefore sets the starting point of my thesis, hence the issue of using crowd simulation as an analysis and design tool will be discussed based on the case study of the Kiev crowded metro lines.

THESIS STATEMENT

The main goal of the project is to develop a design tool which will be able to resolve overcrowded connections in metro stations in different cities like: Mexico City, Kiev, Moscow, Delhi, Shanghai and Tokyo. The tool should have a static basis (universal) and a flexible interface to be adaptable to most metro stations and pedestrian connections. According to the fact that current project will be developed by architect and not programmer the project should represent the strategy and base concept of parametrically defined crowd. The additional goal is to find comparably cheap, fast, functional and logically grounded design solution for Teatralna – Zoloti Vorota metro station and metro network in Kiev.

The aims which are pursued in the current project are following: 1) to develop a design tool to resolve overcrowded connections in metro stations or to prove the irrationality of particular design method. This will be achieved by the usage of parametrically defined human crowd systems as an intelligent shape-generating and testing tool. 2) to show the advantages and disadvantages of particular design method 3) to show the way of making design, zoning and functional decisions using the parametrically defined crowd, also, to show common ways of making the decisions to make both of them comparable to each other. 4) if to talk about the case study of the project the aim is to redesign Teatralna - Zoloti Vorota metro station in Kiev in such a way that the pedestrian traffic between the lines can occur in the most unstressful fashion.

METHODOLOGY

The starting point of the project is the research of the site, crowd behaviour and psychology, Kiev development and Kiev in general. Because Ukraine was part of USSR the over lefts of bureaucracy and corruption are still visible. That is why the statistics is not available for people and probably does not exist at all. The above mentioned fact is making the research analysis quite complex.

Overcrowded metro stations is a usual problem encountered in cities with rapid population growth, old (or undeveloped) infrastructure or a combination of these two (or more) factors. Some of the cities around the world which share at least one of the features mentioned above are: Mexico City (Mexico, North America), Kiev (Ukraine, South-East Europe), Moscow (Russia, East Europe), Delhi (India, Asia), Shanghai (China, Asia) and Tokyo (Japan, Asia).

The site for the project is situated in Kiev (Ukraine), since in this city the problems of population overgrowth and old infrastructure made the pedestrian traffic (and not only) within the metro stations unbearable. Nowadays the biggest problems can be found within the interconnecting stations Teatralna –Zoloti Vorota. Because of the immense number of people which are travelling by metro during the rush hours, the time between trains, including the stops, is about 75-80 seconds. Therefore the connection between the stations and the station platforms themselves are overcrowded, creating not only discomfort and pedestrian “underground traffic jams” but also a threat to human life.

The right bank of Kiev city is situated on 7 hills. This is the reason why the underground system is one of the deepest in the world. The depth or altitude of the platforms is changing from one station to another, from tops 10m above ground level up to 100m under ground level. In the last case it takes around 5 minutes to get from the entrance of the metro station to the deepest platforms.

Both of the above mentioned metro stations were built in the late 80s. The metro stations were designed for a population of 2.000.000. This situation has changed in time, leading to the current official population of 2.800.000 inhabitants. These numbers nevertheless do not reflect the reality of the actual population number of around 4.000.000. This has mainly been accomplished because of the flow of workers which came to Kiev (capital city of Ukraine) after Ukraine got its independence. Therefore it is easy to understand the created situations due to the fact that the population of Kiev doubled since the inauguration of the two stations.

Nowadays Kiev Municipality is not investing anything in the development of the infrastructure and specifically the metro networks because of the economic crisis in 2008. In the same time the project institute “UkrMetroTunnelBuild” has developed projects for 25 metro stations and 3 metro lines. These two facts are giving hope that Kiev metro would be developed in the near future. Nikolay Aleshkin (project leader of “UrkMetroTunnelBuild”) is commenting the Teatralna – Zoloti Vorota station problem: “The problem is obvious but there are no projects and the municipality is even not thinking about redesigning the station. They were designed without thought about the future growth of Kiev.” His proposal is to build additional parallel metro line instead of redesigning one overcrowded station. The information above is bringing more urgency in the current thesis project.

History of “Teatralna” metro station:
It is a station on the Sviatoshynsko-Brovarska Line of the Kiev Metro. It serves as a transfer point, via the pedestrian walkway connecting it to Zoloti Vorota station on the Syretsko-Pecherska Line. The station was opened in 1987, between Universytet and Khreshchatyk stations. Prior to 1992 the station was known as Leninska from its location on Leninska Street. This was renamed in the same year to Khmelnytska Street. In the early 1990s, almost all of the Lenin plaques, statues and individual sculptures were removed from around Kiev, including from other Metro stations. Leninska station was renamed to Teatralna in 1992. However, the statue on the street and bas-relief in the station were retained, among just a handful of surviving Lenin monuments in Kiev. This did cost the director of the metro company, Mykola Shavlovsky, his position. Kiev mayor, Leonid Chernovetsky criticized Shavlovsky for lack of order in the metro. “Everything is left as it was in 1970s”, said the mayor. “Socialism is still left in the metro - just take a ride - the citations of Vladimir Lenin are all around (on Teatralna station). But even Lenin did not want such a metro as it is these days”

History of “Zoloti Vorota” metro station:
It is one of the most famous stations on the Kiev Metro. Named after the Golden Gates historical structure, the station is arguably one of the most stunning achievements in late Soviet architecture. The station was opened as part of the first stage of the Syretsko- Pecherska Line on December 30, 1989. The design contributed a number of architects, but the station itself is due to the masterpiece of Boris and his son Vadim Zhezherin and artistic architects S.Adamenko and M.Ralko. It features a column trivault, with the theme of the Architecture of Kievan Rus, for this the central vault was enlarged to allow for an interior reminiscent of an ancient Russian Orthodox cathedral. When the station was built, it was done as a single unit with its transfer station Teatralna of the Sviatoshynsko-Brovarska Line, which opened two years prior to specifically for the role. The stations are connected with the escalator tunnel coming out of the back of Zoloti Vorota and connecting to the centre of the Tetralna station via staircases. Initially Zoloti Vorota was the northern terminus of the line for exactly seven years. The vestibule of the station (architects T.Tselikovskaya, A.Krushinky and F.Zaremba) was built into a building on the corner of Volodymyrska street and Zoloti Vorota driveway, next to the ancient historical memorial. Due to the station’s location and depth there are two separate escalator paths that connect via an intermediate lobby.

“UrkMetroTunnelBuild” and “KievMetroBuild” are half secret and bureaucratic institutions because the metro building rules are the same as they used to be during USSR times. Every underground metro station has bunkers intended for thousands of people in case of nuclear or biochemical war. This is one of the reasons why the statistics and drawings are hidden from the civil people. Therefore all the statistics in the project relevant to the passenger flow was taken from videos made on the stations and manually calculated in 7 different points (entrances to the metro stations, platforms and from the connection path), 3 times per day (morning rush hour, midday and evening rush hour) and on a weekdays.

Human crowd behaviour is very similar to other crowds (like animals, birds, fishes). Scientists, sociologists, psychologists were and still are studying a the behaviour of individuals within crowds (the individual crowd member will be referred to further on as “boid”) and made big progress it current topic. But still they have different opinions and publishing different results of their research. What is common for all of them are the three basic rules of a boid in a crowd as mentioned and applied for the first time in 1986 by Craig W. Reynolds. He defined the main rules of the boid as being: separation[1], cohesion[2] and alignment[3]. According to the topic of the current project there will be several other rules applied, which will make the virtual model be closer to reality and able to represent as much as possible details of the process. The particular rules on which each boid in the developed tool will react upon are: danger[4], goal seeking[5], avoidance[6], obstacles avoidance[7], bounce[8], blocked view[9], field of view (57°direct and 145° indirect)[10], hearing 360°[11], wrong way because of neighbour[12].

The scripting (programming) process is based on mathematical rules. In the script most of the operations will be based on vector mathematics. The complexity of the task is: 1. every boid has three vectors – position, - velocity, - acceleration, also it has a target (exit from the stations or going to another platform). Amount, speed, targets and frequency of boids is set up according to the research made on the site; 2. every small step (0,03 seconds) every boid is analysing its neighbouring conditions - such as their position, direction, targets, speed, horizontality (are they moving horizontal or not), etc - in order for it to perform in a more efficient way. Based on the received data from the neighbours, the boids velocity and acceleration are changing; 3. Information of all the moves and positions is stored for further analysis (e.g. in high density areas guide way barriers and sings are appearing); 4. next step is to check new design proposal again with the parametrically defined crowd tool to find and change any areas of high density etc.

The expected result should represent the qualities of the parametrically defined crowd tool. The qualities will be estimated to find advantages and disadvantages of the tool to proceed with it to the next step of development.

CONCLUSION

The crowd tool that is being developed upon a case study will be analysed for its applicability in resolving issues of high density people circulation. In the same sense the applicability of this kind of design tools will be analysed through understanding both the procedures an methods applicable and analysis of the results.

KEY WORDS

separation - is the rule which steers the boid[13] away from the others/neighbours

cohesion - the rule which holds the crowd together and steers the boids[13] towards each other/neighbours

alignment - the rule which is setting the direction and steers the boid[13] in average direction between others/neighbours.

danger - the rule which is spreading the crowd and steers the boid[13] away from visible or audible danger

goal seeking - the rule which steers the boids[13] to their destination or follows the path to the destination

avoidance - one of the main rules within the crowd systems which is helping the boids[13] to not crash into each other

obstacles avoidance - the rule which changes the direction of the movement of the boids[13] in order to avoid obstacles

bounce - if an obstacle gets touched, the boid[13] bounces off that obstacle

blocked view - the rule which is allowing the boid[13] to “communicate” only with boids[13]/targets which are within a specified range

field of view (57°direct and 145° indirect) - the rule which is allowing

the boid[13] to “communicate” only with boids[13]/targets which are within a specified angle

hearing 360° - the rule which is allowing the boid[13] to “hear” within a specified range/angle

wrong way because neighbour - the rule which is forcing one boid[13] to steer in another direction because of the main direction of a flock of boids[13]

boid – the term for a generic simulated crowd member, which Raynolds invented.

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