**Navigation in Google Maps using Leap Motion and   
Google Maps API V3**

LICENSE THESIS

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|  | Supervisor: | **todo Adrian GROZA** |

**2014**

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1. **Project proposal:** *Short description of the license thesis and initial data*
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3. **Place of documentation**: *Example*: Technical University of Cluj-Napoca, Computer Science Department
4. **Consultants**:
5. **Date of issue of the proposal:** November 1, 2013
6. **Date of delivery:** June 28, 2014 (*the date when the document is* *submitted*)

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|  |  | Semnătura |

**De citit înainte** (această pagină se va elimina din versiunea finală):

1. Cele trei pagini anterioare (foaie de capăt, foaie sumar, declaraţie) se vor lista pe foi separate (nu faţă-verso), fiind incluse în lucrarea listată. Foaia de sumar (a doua) necesită semnătura absolventului, respectiv a coordonatorului. Pe declaraţie se trece data când se predă lucrarea la secretarii de comisie.
2. Pe foaia de capăt, se va trece corect titulatura cadrului didactic îndrumător, în engleză (consultaţi pagina de unde aţi descărcat acest document pentru lista cadrelor didactice cu titulaturile lor).
3. Documentul curent a fost creat în **MS Office 2007.** Dacă folosiţi alte versiuni e posibil sa fie mici diferenţe de formatare, care se corectează (textul conţine descrieri privind fonturi, dimensiuni etc.).
4. **Cuprinsul** începe pe pagina nouă, impară (dacă se face listare faţă-verso), prima pagina din capitolul **Introducere** tot aşa, fiind numerotată cu 1. Pentru actualizarea cuprinsului, click dreapta pe cuprins (zona cuprinsului va apare cu gri), Update field->Update entire table.
5. Vizualizaţi (recomandabil şi în timpul editării) acest document după ce activaţi vizualizarea simbolurilor ascunse de formatare (apăsaţi simbolul **** din *Home/Paragraph*).
6. Fiecare capitol începe pe pagină nouă, datorită simbolului ascuns Section Break (Next Page) care este deja introdus la capitolul precedent. Dacă ştergeţi din greşeală simbolul, se reintroduce (*Page Layout -> Breaks*).
7. Folosiţi stilurile predefinite (Headings, Figure, Table, Normal, etc.)
8. Marginile la pagini nu se modifică (Office 2003 default).
9. Respectaţi restul instrucţiunilor din fiecare capitol.

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# Introduction (Heading 1 style)

The title of each chapter is formatted using Heading 1 style, numbering with one digit (Chapter x. Chapter Name ), font Times New Roman, size 14 points, Bold.

This chapter will present:

* Project context,
* Specification of the precise domain of the license thesis,
* Use about 5% of the paper.

## Project context (Heading 2 style)

The font used for the text in this document is Times New Roman, size 12 points, as defined in the *Normal style*, Line spacing equal to 1.0 (Paragraph, Line spacing) and *Justify*.

The first line for each paragraph must be indented (implicit in *Normal Style*), and no additional space is inserted between successive paragraphs.

### (Heading 3 style)

Each table used in this document is labeled as Table x.y, where x represents the chapter number, and y shows the table number within the current chapter. Leave a blank line between and after each table, relative to the adjacent paragraphs.

Table 1.1 (References, Insert caption->Table)

|  |  |  |  |  |
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| Times new roman ( 12) | Xxxx | xxxx | xxxx |  |
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Each figure used in the document must be cited within the text (ex: in figure x.y the system components are presented... ) and labeled. The labeling must be as Figure x.y where x represents the chapter number, and y shows the number of the figure within the current chapter. Use (References, Insert caption->Figure).



Figure 1.1 Description (References, Insert caption->Figure)

Each chapter must start on a new page.

# Project Objectives

The project theme must be described in this chapter (as a research/design proposal, clearly formulated, with clear objectives 2-3 pages, and some explanatory figures).

Should represent about 10% of the paper.

# Bibliographic Research

**Todo: Write short introduction for this chapter**

**Todo: min requirements leapmotion.com/setup**

## Related work

This section of the thesis briefly reviews related work in the areas directly associated with Leap Motion Controller and Google Maps API. Finally, conclusions will be drawn in order to accentuate the pluses and the contribution of this thesis in the fields mentioned above.

### Leap Motion and Google Earth

One of the most known application that is available in this field is the *Google Earth* plugin developed by Google themselves. The plugins allows the user to travel the world through a virtual glove and view satellite imagery, maps, terrain and 3D buildings [1]. Even though the solution provided by Google is quite unique and comes with a lot of features, the plugin comes with some downsides and some flaws.

From the beginning we can see that the plugin is way too sensitive to use. Trying to control the application out of the box can be a disaster since manipulating the space can be quite difficult. The earth can get into a state when is constantly spinning, the motion speed while using the plugin is varying too much because of the high sensibility and sometimes the movements are too large, fast or out of control. Another downside of Google Earth plugin is that you need to have installed Google Earth (which is a software that requires relatively high system settings, such as: 2GB+ free hard disk space, a network speed of 768 Kbits/sec and so on [2]).

### Leap Motion and Hyperlapse (by Teehan+Lax Labs)

The developers from Teehan+Lax Labs [3] have come up with a solution that is able to create hyper-lapse[[1]](#footnote-1) videos from Google Street View panoramas. Because of the fact that the original code of the hyperlapse.js is available on GitHub I investigated their solution: two locations must be defined, using Google Maps’ public Routing API a route is being computed between that two locations and all the panoramas available between this two locations are downloaded and cached into the browser memory and then stitched up together using GSVPano.js. After all the images are downloaded, using Three.js the movement between frames is being implemented.

The only big problem here is that this innovative library for Google Maps Street View, Hyperlapse.js, **breaks one of the Google Maps’ terms of agreement**, which is: “you must not use the Products in a manner that gives you or any other person access to mass downloads or bulk feeds of any Content” (more information can be found under 2(d) in the Google Maps/Earth Terms of Service [4]).

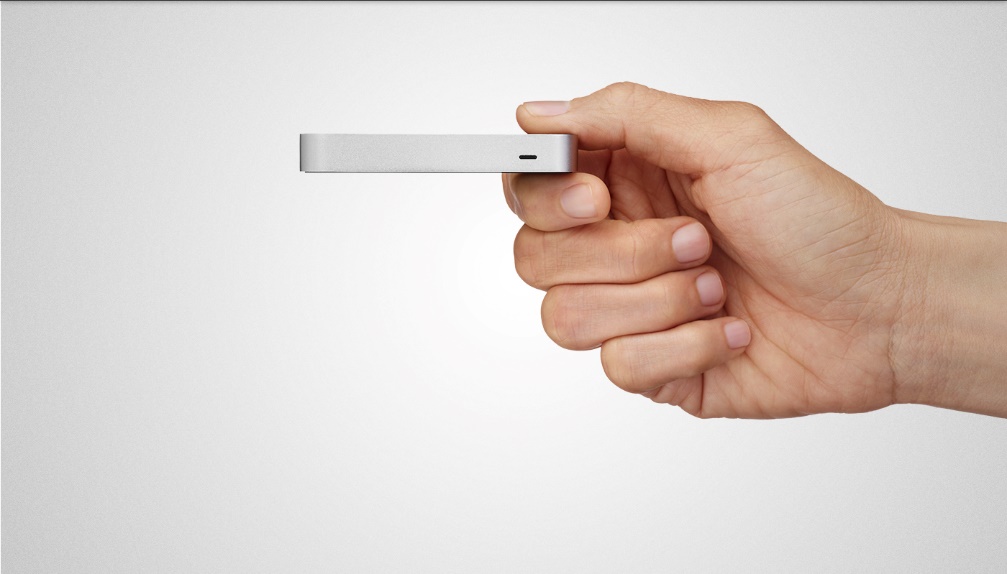
The app is entirely written in Javascript using LeapJS and a modified version of Hyperlapse.js [5].

## Leap Motion

The *Leap Motion* *controller* is a computer hardware 3D sensor device that supports hand and finger motions as input, but it does not require any hand contact leaving the hand navigate free into the air. The *Leap Motion Controller* senses how you naturally move your hands and lets you use your computer in a whole new way. The *Leap Motion controller* (Figure 3.1) is sleek, light (45 grams) and has relatively small dimensions, being 80 mm long, 12.7 mm tall and having a width of 30 mm [6].

*The Leap Motion Controller* represents a revolutionary input device for gesture-based human-computer interaction. It allows for the precise and fluid tracking of multiple hands, fingers, and small objects in free space with sub-millimeter accuracy.

Figure 3.1 The *Leap Motion* *controller*



### Leap Motion technology

The *Leap Motion* *controller* is an input peripheral device with an USB connector. The device uses two monochromatic IR cameras and three infrared LEDs. As we can see from *Figure 3.2*, the *Leap Motion controller* scans a region in the shape of an inverted pyramid centered at the device’s center and extending upwards. Therefore, the controller can be categorized as an optical tracking system based on the stereo vision principle. The Leap software analyzes the objects observed in the device’s field of view. It recognizes hands, fingers, and tools, reporting discrete positions, gestures, and motion.

The effective range of the controller extends from approximately 25 to 600 millimeters above the device



Figure 3.2 *Leap Motion’*s field of view

The device itself was made publicly available in summer 2013, and therefore not much scientific work has been published yet

## Leap Motion alternatives

In this chapter I will enumerate and briefly describe what other computer hardware 3D sensors devices are available on the market in the gesture detection field and what are their pluses and minuses.

### Wii (by Nintendo)

In the domain of gesture detection, one of the first accurate and commercially viable solutions was the Nintendo Wii controller. The Wii controller, released in 2006, looks like a TV remote and was designed as a game controller. The primary control of the movement is the controller itself, containing solid-state accelerometers that let it sense full 3D gestures patters, such as:

* Tilting and rotation up, down, left and right
* Rotating along the main axis (as with a screwdriver)
* Acceleration up, down, left and right
* Acceleration towards the screen and away [7]

Because of the fact that the WiiMote can operate as a separate device, it was used in many applications that worked with a computer.

Compared with the Leap Motion Controller, the WiiMote can detect hand gestures in the air field, but it has no information about the fingers position, alignment and gestures.

### Kinect (by Microsoft)

The Kinect, developed by Microsoft and released in 2010, comes as an add-on sensor for the Xbox 360 gaming console. The controller has visual and auditory (voice recognition) inputs and includes a 3D depth-sensing camera which gives the opportunity to the developers to incorporate, acquire and recognize full body gestures of multiple users at a time. Moreover, having an open SDK allows the developers to integrate this controller in other fields also, allowing it to detect other objects than human bodies.

Gathering massive amounts of data from motion-capture in real-life scenarios, the Kinect developers processed that data using a machine-learning algorithms and they were able to map the data to models representing people of different ages, body types, genders and clothing. With select data, developers were able to teach the system to classify the skeletal movements of each model, emphasizing the joints and distances between those joints [8].

However, in comparison with the Wii controller, the Microsoft Kinect allows the full body gesture recognition, instead of only hand movement recognition, but compared with the Leap Motion controller it has no precision at the level of fingers.

### Asus Xtion Live

### http://intugine.com/

Bibliographic research has as an objective the establishment of the references for the project, within the project domain/thematic. While writing this chapter (in general the whole document), the author will consider the knowledge accumulated from several dedicated disciplines in the second semester, 4th year (Project Elaboration Methodology, etc.), and other disciplines that are relevant to the project theme.

Represents about 15% of the paper.

References will be included in the *Bibliography* section. The reference format must be IEEE, or similar. The introduction of new references in the *Bibliography* section, and their citation within the document text can be done manually (by obeying the format), but it is less recommended, or by using the tools mentioned in the last paragraphs of this chapter.

In the *Bibliography* section, there are examples of references to conferences or workshops articles [1], journal articles [2], and books [3]. References to applications or online resources (web pages) must include at least a short relevant description in addition to the link [4], and other information is available (authors, year, etc.). References that contain only the link to the online resource will be placed in the page footer.

Each reference must be cited within the document text, see example below (depending on the project theme, the presentation of a method/application can vary).

In paper [1] the authors present a detection system for moving obstacles based on stereovision and ego motion estimation. The method is … *discus the algorithms, data structures, functionality, specific aspects related to the project theme, etc*…. Discussion: *pros and cons*.

In chapter 4 of [3], the *similar-to-my-project-theme algorithm* is presented, with the following features…

Software and other tools managing bibliography for **MS Word 2003**, and usage instructions can be found at:

[How to use JabRef (BibTeX) with Microsoft Word 2003](http://www.medicalnerds.com/how-to-use-jabrefbibtex-with-microsoft-word-2003/)

[Bibtex4Word](http://www.ee.ic.ac.uk/hp/staff/dmb/perl/index.html)

[BibWord makes it easier to create and manipulate Microsoft Word citation and bibliography styles](http://www.codeplex.com/bibword)

For **MS Word 2007** and **MS Word 2010**, the integrated bibliography management system should be used, *References, Citations & Bibliography.* More information can be found in the online documentation of MS Office.

# Analysis and Theoretical Foundation

Together with the next chapter takes about 60% of the whole paper.

The purpose of this chapter is to explain the operating principles of the implemented application.

Here you write about your solution from a theory standpoint – i.e. you explain it and demonstrate its theoretical properties/value, e.g.:

* used or proposed algorithms,
* used protocols,
* abstract models,
* logic explanations/arguments concerning the chosen solution,
* logic and functional structure of the application, etc.

YOU DO NOT write about implementation.

YOU DO NOT copy/paste info on technologies from various sources and others alike, which do not pertain to your project (no fillers, please!).

# Detailed Design and Implementation

Together with the previous chapter takes about 60% of the paper.

The purpose of this chapter is to document the developed application such a way that it can be maintained and developed later. A reader should be able (from what you have written here) to identify the main functions of the application.

The chapter should contain (but not limited to):

* a general application sketch/scheme,
* a description of every component implemented, at module level,
* class diagrams, important classes and methods from key classes.

# Testing and Validation

This chapter is

TODO: Write introduction to this chapter

## Leap Motion precision and reliability

### Spatial positioning

The study’s goals on which this subchapter is based was to analyze the precision and reliability of the *Leap Motion Controller* in static and dynamic conditions and to determine its suitability as an economically attractive finger/hand and object tracking sensor [7].

Two types of measurements were performed within the experiment, under two experimental conditions:

* Static conditions: acquisition of a limited number of static points in space (3,000 measurements were taken of 37 positions)
* Dynamic conditions: tracking of moving objects with constant inter-object distance within the calibrated space (119,360 measurements were taken in an attempt to cover the estimated useful sensory space of the controller)

The results of the study, in the *static scenario*, are presented in the 6.1 Table. As we can see, the standard deviation is less than 0.5 mm at all times, therefore we can say that the controller is quite precise and accurate in determining the static positioning in space.

Table 6.1 Results of static study

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Standard deviation | x Axis | y Axis | z Axis | Spatial position |
|  | position | (stdx) | (stdy) | (stdz) | (std) |
| Minimal  std | std(mm) | **0.0081** | 0.0093 | 0.015 | 0.013 |
| location(x, y, z) (cm) | (0, 30, 0) | (-10,-10,-5) | (0, 20, -5) | (0, 15, 0) |
| Maximal  std | std(mm) | 0.39 | **0.49** | 0.37 | 0.38 |
| location(x, y, z) (cm) | (-20, 20,0) | (-20, 30, 0) | (-20, 30, 0) | (-20, 30,0) |

The lowest standard deviation (0.0081 mm) was measured on the x axis at 30 cm above the controller, while the highest standard deviation (0.49 mm) was measured on the y axis at the leftmost and topmost positions [7]. In terms of spatial positioning, the results show a minimal standard deviation of 0.013mm (when the object is positioned right above the controller at 15mm height), while the maximum standard deviation of 0.38 mm was measured at 20cm on the left hand side of the controller and 30cm height.

The set of measurements in the *dynamic scenario* revealed that the accuracy of the controller drops when the objects move away from the sensor, therefore resulting in an inconsistent performance of the controller.

Previous similar tests were done using a robotic arm, both in static and dynamic scenarios, in order to measure the precision of the sensor [8]. The study from 2013 was focused on an early version of the Leap Motion Controller taking into account the so-called tremor (defined as an involuntary and approximately rhythmic movement of muscles). Depending on the human age, the tremor value can be in the range of 0.4mm ± 0.2mm (for young adults) to 1.1mm ± 0.6 mm (for older adults) [9]. The study from 2013 has revealed even bigger standard deviations, therefore this proves that the Leap software has improved from earlier phases by now, and even though this deviation occurs, the study has shown that comparable controllers in the same price range (e.g., the Microsoft Kinect) were not able to achieve the accuracy that the Leap Motion has [8].

From the studies presented above, we can draw the conclusion that the accuracy of the Leap Motion controller decreases when the objects are moving away from the sensor and when moving to the far left or right of the controller. However, having a relatively low standard deviation (less than 0.5 mm at all times [7]), the controller can be considered, in my opinion, a very good tool, with a high quality/price ratio, for personal use, but not as a professional tracking system.

### Gesture recognition

As we can see, the Leap Motion Controller has very good precision and accuracy, but when it comes to Gesture recognition, the Leap software has some flaws.

The Leap Motion software recognizes certain movement patterns as gestures which could indicate a user intent or command. The following movement patters are recognized by the Leap Motion software:

* *Circle* (a single finger tracing a circle),
* *Swipe* (A long, linear movement of a finger),
* *Key Tap* (A tapping movement by a finger as if tapping a keyboard key) and
* *Screen Tap* (a tapping movement by the finger as if tapping a vertical computer screen) [10].

The software lacks accuracy in detecting the right movement at the right time, but does not lack of accuracy and precision in terms of hand positioning. To illustrate this issue manual tests were done. I, as a user, I intended to perform 50 gestures of each type mentioned above, and I noted down the results that the Leap Motion has given and have built charts from it.

**NOTE**: The results can vary from one user to another. The Leap software does not have a learning algorithm implemented, but the user can learn the patterns that the Leap software recognizes and try to mimic them.

#### Circle gesture

A circle gesture is defined as a single finger tracing a circle. For this test, I intended to perform 50 circle gestures (both clockwise and counter-clockwise) positioning my hand in different parts of the interaction box above the controller. Out of 50 gestures performed, 45 were detected as *circles* and 5 were detected as *key taps* (see Figure 6.1).

Figure 6.1 Circle gesture

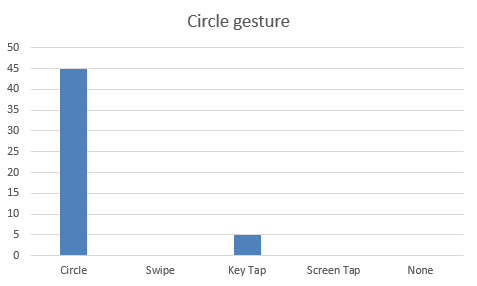


Figure 6.1 Circle gesture statistics

#### Swipe gesture

A swipe is defined as a long linear movement of a finger or hand. This gesture is highly used in mobile application industry (e.g. unlocking the screen, navigating through screens or photos, etc.).

Out of 50 gestures performed, only 28 were detected as swipe gestures, 10 were not detected at all, and the rest were detected as either key taps or circle gestures (see Figure 6.2).

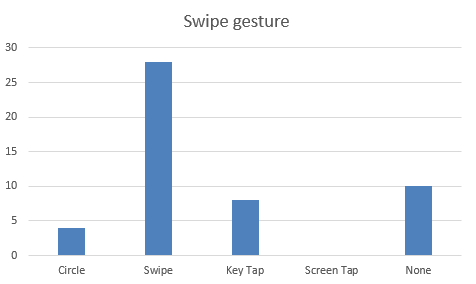


Figure 6.2 Swipe gesture statistics

#### Key Tap gesture

The Key Tap gesture is defined as a movement representing a finger tapping downwards and back upwards as if tapping a keyboard key. As we can see from the image below (Figure 6.3), the Key Tap gesture is the gesture which is the most easily detected by the Leap software, out of 50 gestures performed, 48 were registered as key taps and two gestures were not recognized.

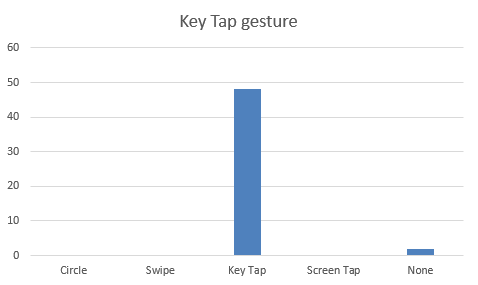


Figure 6.3 Key Tap gesture statistics

#### Screen Tap gesture

A tapping movement by the finger as if tapping a vertical computer screen (moving forward on the z axis and then backwards) describes a *Screen Tap* gesture.

I have to mention that it took me quite some time to learn the gesture, at the very beginning of the implementation the project, I had problems reproducing the gesture, most of the times the Leap software not recognizing gesture interaction while trying to perform a screen tap.

Therefore, in the Figure 6.4, we can notice that out of 50 gestures performed, 35 were detected as screen taps, 10 gestures were not detected, three of them were classified as being circle gestures and one as a key tap.

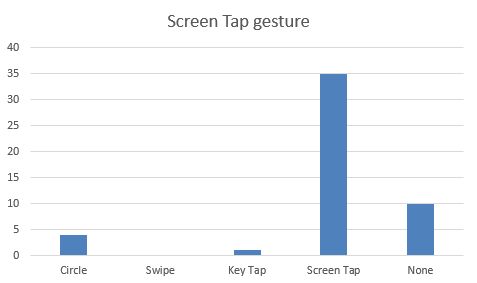


Figure 6.4 Screen Tap statistics

In conclusion, after I have performed the manual tests, summing it all up, in 78% of the cases the gesture was correctly detected and classified, 11% of times the gesture was misclassified and also 11% of the times the gesture was not detected at all (see Figure 6.5)

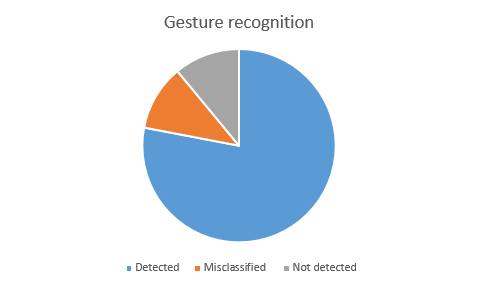


Figure 6.5 Gesture recognition statistics

I would say that the Leap Motion Controller is a very good option for detecting the spatial position in terms of 3D in the interaction box that is available above the controller itself, but not quite such a good option, at the moment when the document is written, for detecting movement patterns. Even if 78% is a quite high number, there still are approximately 2 times out of 10 when the controller, and implicitly the product developed will not act as it should. The lack of gesture detection (11%) is not quite concerning from my point of view, but detecting other gesture than performed in 11% of the times is quite concerning because there could be other implementations available for different gestures and then this will result in an unexpected and unwanted behavior of the product developed.

The Leap Motion Controller’s lack of artificial intelligence involvement in the software (i.e., not being able to adapt with the user interaction and to learn its behavior) could force the developers to give up at all the gesture implementation and integration in the product that is being developed in order to avoid performance issues and unwanted behavior that might occur because of the lack of accuracy in detecting the right moves at the right time.

## Performance

FPS, 2 desplays

## 

About 5% of the paper. (2-3 pag)

# User’s manual

In the installation description section your should detail the hardware and software resources needed for installing and running the application, and a step by step description of how your application can be deployed/installed. An administrator should be able to perform the installation/deployment based on your instructions.

In the user manual section you describe how to use the application from the point of view of a user with no inside technical information; this should be adorned with screen shots and a stepwise explanation of the interaction. Based on user's manual, a person should be able to use your product

# Conclusions

About. 5% of the whole.

In this chapter you present:

* A summary of your contributions/achievements,
* A critical analysis of the results achieved,
* A description of the possibilities of improvements/further development.

# Bibliography

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# Appendix 1 (only if needed)

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Relevant code sections

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Other relevant info (proofs etc.)

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Published papers (if any)

etc.

1. A hyper-lapse is an exposure technique in time-lapse photography, in which the position of the camera is being changed between each frame in order to create a tracking shot [11]. [↑](#footnote-ref-1)