

# 3D-Kopiering

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Skriva ut uppmätta 3D objekt med en 3D-skrivare

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## Abstract

Abstract.tex

# Författarens tack

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# 1 Inledning

## 1.1 Motivering

I den här rapporten kommer du bevittna framtidens teknik. 3D-kopiering gör det möjligt att kлона ett valfritt objekt i valfri upplösning. En avståndskamera gör det möjligt att skanna en 3D bild av ett objekt i verkligheten för att importera detta objekt till en 3D modell i datorn. I datorn kan sedan modellen hanteras och moduleras till önskad effekt nås. Modellen kan sedan skrivas ut i sin nya form med hjälp av en 3D-skrivare. Rapporten kommer att redogöra hur framställningen av en mjukvara till ett system för 3D-kopiering går till.

[scigen]

This is where the studied problem is described from a general point of view and put in a context which makes it clear that it is interesting and well worth studying. The aim is to make the reader interested in the work and create an urge to continue reading.

## 1.2 Syfte

Syftet med projektet är att utveckla en produkt som gör det möjligt att kлона ett valfritt objekt. Projektet bygger vidare på en tidigare utvecklad mjukvara som skapats av tidigare års kandidatprojekt. Den redan befintliga mjukvaran gör det möjligt att styra den tillhandahållna hårdvaran som består av ett rotationsbord samt en linjärenhet där en avståndskamera kan förflyttas på. Syftet är alltså att vidareutveckla det system som redan finns för att göra det möjligt att kлона objekt till en valfri storlek. Systemet ska alltså genom att skanna objektet omvandla det till punktmoln. Med dessa punktmoln ska sedan ett 3D objekt skapas, för att sedan skriva ut det med en tillhandahållen 3D-skrivare. Systemet ska vara modulärt, väl byggt och enkelt att förstå för att göra det möjligt för vidareutveckling, forskning samt för eventuell användning till laborationer.

What is the underlying purpose of the thesis project?

## 1.3 Frågeställning

Projektgruppen vill att systemet ska vara användbart för kunden. Systemet ska tänkas användas till vidareforskning eller för laborationer i kurser på Linköpings universitet. En av frågeställningarna som rapporten kommer ta upp är således hur systemet kan implementeras

så att det maximerar värdet för kunden. En annan frågeställning som rapporten kommer att ta upp är hur systemet kan vidareutvecklas för framtida projekt. Denna vidareutveckling kommer baseras på de erfarenheter som projektet medför.

This is where the research questions are described. Formulate these as explicit questions, terminated with a question mark. A report will usually contain several different research questions that are somehow thematically connected. There are usually 2-4 questions in total.

Examples of common types of research questions (simplified and generalized):

1. Hur kan system X implementeras så att man skapar värde för kunden?
2. Vilka erfarenheter kan dokumenteras från programvaruprojekt Y som kan vara intressanta för framtida projekt?
3. Vilket stöd kan man få genom att skapa och följa upp en systemanatom?
4. Specifika frågeställningar.

Observe that a very specific research question almost always leads to a better thesis report than a general research question (it is simply much more difficult to make something good from a general research question.)

The best way to achieve a really good and specific research question is to conduct a thorough literature review and get familiarized with related research and practice. This leads to ideas and terminology which allows one to express oneself with precision and also have something valuable to say in the discussion chapter. And once a detailed research question has been specified, it is much easier to establish a suitable method and thus carry out the actual thesis work much faster than when starting with a fairly general research question. In the end, it usually pays off to spend some extra time in the beginning working on the literature review. The thesis supervisor can be of assistance in deciding when the research question is sufficiently specific and well-grounded in related research.

## 1.4 Avgränsningar

This is where the main delimitations are described. For example, this could be that one has focused the study on a specific application domain or target user group. In the normal case, the delimitations need not be justified.



## 2 Bakgrund

Kunden i detta projekt var Avdelningen för datorseende (CVL), institutionen för systemteknik (ISY) vid Linköpings tekniska högskola. Som tidigare nämnts så är detta projekt en uppföljning på ett projekt som utfördes våren 2016. CVL bedriver utbildning och forskning om signalbehandling, bildanalys, datorseende, beräkningsfotografi; detektion, följning och igenkänning av objekt; skattning av pose och 3D-struktur; robotseende och autonoma system; medicinsk bildanalys och bildrekonstruktion. Systemet som användes i projektet var först uppbyggt av en doktorand som använde det i ett forskningsprojekt. Efter detta bestämde CVL att systemet skulle om-användas, och kom med förslaget att använda avståndskameran i kurser relaterade till bildsensorteknik och att utlysa ett kandidatprojekt för att vidareutveckla systemet med en inriktning mot att kunna använda det för att skanna tre dimensionella objekt och sedan skriva ut dem med en 3D-skrivare. Det första kandidatprojektet (våren 2016) hade som mål att dekonstruera rotationsbordet (som var specialbeställt och levererades utan teknisk dokumentation) och sedan implementera styrning av systemet och generering av punktmoln. Efter projektet utlyste CVL ett nytt kandidatprojekt vars mål var att vidareutveckla det befintliga systemet för att till slut kunna använda det för att skriva ut skannade objekt. CVLs mål med det system som nu är utvecklat är att använda det i forskning kring punktmoln, b.l.a. vidareutveckling av C++ biblioteket PCL (Point Cloud Library), och annan forskning kring avståndskamerateknik och 3D-skrivarteknik. CVL har även en tanke om att använda systemet för att skapa hinder som kommer att användas i deras nya labb för obemannade farkoster och att konstruera laborationer som använder systemet. Projektgruppen består (som nämnts tidigare) av studenter vid D (Civilingenjörsutbildning i datateknik) och U (Civilingenjörsutbildning i mjukvaruteknik) programmen vid Linköpings tekniska högskola. Tidigare mjukvaruutvecklingserfarenhet har alla gruppmedlemmar fått genom kurser på respektive program. För de medlemmar som läser D programmet är projektkursen "Konstruktion med mikrodatorer" den kurs som gett mest erfarenhet av att jobba med ett utvecklingsprojekt i grupp. Kursen gick ut på att, i grupp, konstruera en robot. För de medlemmar som går U programmet är det kursen "Artificiell intelligens - projekt" som gett mest erfarenhet av att jobba med ett utvecklingsprojekt i grupp. Kursen gick ut på att, i grupp, identifiera relevanta AI-tekniker och litteratur som beskriver dem för att sedan utvärdera och jämföra dessa tekniker relativt varandra. Slutligen implementerades och integrerades dessa AI-tekniker i ett valfritt system.





## 3 Teori

The main purpose of this chapter is to make it obvious for the reader that the report authors have made an effort to read up on related research and other information of relevance for the research questions. It is a question of trust. Can I as a reader rely on what the authors are saying? If it is obvious that the authors know the topic area well and clearly present their lessons learned, it raises the perceived quality of the entire report.

After having read the theory chapter it shall be obvious for the reader that the research questions are both well formulated and relevant.


The chapter must contain theory of use for the intended study, both in terms of technique and method. If a final thesis project is about the development of a new search engine for a certain application domain, the theory must bring up related work on search algorithms and related techniques, but also methods for evaluating search engines, including performance measures such as precision, accuracy and recall.

The chapter shall be structured thematically, not per author. A good approach to making a review of scientific literature is to use *Google Scholar* (which also has the useful function *Cite*). By iterating between searching for articles and reading abstracts to find new terms to guide further searches, it is fairly straight forward to locate good and relevant information, such as [test].

Having found a relevant article one can use the function for viewing other articles that have cited this particular article, and also go through the article's own reference list. Among these articles one can often find other interesting articles and thus proceed further.

It can also be a good idea to consider which sources seem most relevant for the problem area at hand. Are there any special conference or journal that often occurs one can search in more detail in lists of published articles from these venues in particular. One can also search for the web sites of important authors and investigate what they have published in general.

This chapter is called either *Theory*, *Related Work*, or *Related Research*. Check with your supervisor.



## **4 Metod**

### **4.1 Utvecklingsmetod**

### **4.2 Metod för att fånga erfarenheter**

In this chapter, the method is described in a way which shows how the work was actually carried out. The description must be precise and well thought through. Consider the scientific term replicability. Replicability means that someone reading a scientific report should be able to follow the method description and then carry out the same study and check whether the results obtained are similar. Achieving replicability is not always relevant, but precision and clarity is.

Sometimes the work is separated into different parts, e.g. pre-study, implementation and evaluation. In such cases it is recommended that the method chapter is structured accordingly with suitable named sub-headings.



## **5 Resultat**

### **5.1 Systembeskrivning**

### **5.2 Gemensamma erfarenheter**

### **5.3 Översikt över individuella bidrag**

This chapter presents the results. Note that the results are presented factually, striving for objectivity as far as possible. The results shall not be analyzed, discussed or evaluated. This is left for the discussion chapter.

In case the method chapter has been divided into subheadings such as pre-study, implementation and evaluation, the result chapter should have the same sub-headings. This gives a clear structure and makes the chapter easier to write.

In case results are presented from a process (e.g. an implementation process), the main decisions made during the process must be clearly presented and justified. Normally, alternative attempts, etc, have already been described in the theory chapter, making it possible to refer to it as part of the justification.



## **6 Diskussion**

This chapter contains the following sub-headings.

### **6.1 Results**

Are there anything in the results that stand out and need be analyzed and commented on? How do the results relate to the material covered in the theory chapter? What does the theory imply about the meaning of the results? For example, what does it mean that a certain system got a certain numeric value in a usability evaluation; how good or bad is it? Is there something in the results that is unexpected based on the literature review, or is everything as one would theoretically expect?

### **6.2 Method**

This is where the applied method is discussed and criticized. Taking a self-critical stance to the method used is an important part of the scientific approach.

A study is rarely perfect. There are almost always things one could have done differently if the study could be repeated or with extra resources. Go through the most important limitations with your method and discuss potential consequences for the results. Connect back to the method theory presented in the theory chapter. Refer explicitly to relevant sources.

The discussion shall also demonstrate an awareness of methodological concepts such as replicability, reliability, and validity. The concept of replicability has already been discussed in the Method chapter (4). Reliability is a term for whether one can expect to get the same results if a study is repeated with the same method. A study with a high degree of reliability has a large probability of leading to similar results if repeated. The concept of validity is, somewhat simplified, concerned with whether a performed measurement actually measures what one thinks is being measured. A study with a high degree of validity thus has a high level of credibility. A discussion of these concepts must be transferred to the actual context of the study.

The method discussion shall also contain a paragraph of source criticism. This is where the authors' point of view on the use and selection of sources is described.

In certain contexts it may be the case that the most relevant information for the study is not to be found in scientific literature but rather with individual software developers and open

source projects. It must then be clearly stated that efforts have been made to gain access to this information, e.g. by direct communication with developers and/or through discussion forums, etc. Efforts must also be made to indicate the lack of relevant research literature. The precise manner of such investigations must be clearly specified in a method section. The paragraph on source criticism must critically discuss these approaches.

Usually however, there are always relevant related research. If not about the actual research questions, there is certainly important information about the domain under study.

### **6.3 The work in a wider context**

There must be a section discussing ethical and societal aspects related to the work. This is important for the authors to demonstrate a professional maturity and also for achieving the education goals. If the work, for some reason, completely lacks a connection to ethical or societal aspects this must be explicitly stated and justified in the section Delimitations in the introduction chapter.

In the discussion chapter, one must explicitly refer to sources relevant to the discussion.



## 7

## Conclusion

This chapter contains a summarization of the purpose and the research questions. To what extent has the aim been achieved, and what are the answers to the research questions?

The consequences for the target audience (and possibly for researchers and practitioners) must also be described. There should be a section on future work where ideas for continued work are described. If the conclusion chapter contains such a section, the ideas described therein must be concrete and well thought through.



## 8 Discussion

This chapter contains the following sub-headings.

### 8.1 Results

Are there anything in the results that stand out and need be analyzed and commented on? How do the results relate to the material covered in the theory chapter? What does the theory imply about the meaning of the results? For example, what does it mean that a certain system got a certain numeric value in a usability evaluation; how good or bad is it? Is there something in the results that is unexpected based on the literature review, or is everything as one would theoretically expect?

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