Rendering Invisibility

Report Name	Outline Project Specification
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1. Project description

The aim of the project is to produce a working model of a spherical or cylindrical invisibility cloak using recent research and advances in the theory of invisibility. This model will be created in a 3D graphics language and will be used to obtain results about how well current theories are working towards creating an invisibility cloak against visible light, what drawbacks are there and what is causing them, and how does the cloak affect visibility from inside the cloak and therefore it's use for moving around invisible.

It is essential that the cloak is created in such a manner that it takes into account all the mathematical theories about how such a cloak is possible, looking mostly into transformation optics and the ideas presented there, and also the idea of metamaterials, as these are a key part in creating a real cloak of invisibility. Metamaterials are materials where the structure is designed to cause some kind of effect, such as the metamaterials designed to cause light to negatively refract or to be invisible from radio waves without disrupting the electromagnetic field.

The end goal is to see if we can model the invisibility cloak, how well the invisibility cloak works and what strengths and limitations exist within current theory. There is also room for creating multiple models if possible, looking at comparisons between spherical and cylindrical models, different global illumination strategies and how these affect the invisibility cloak's strengths and weaknesses.

2. Proposed tasks

The first task that needs completing is research. This research will aim to give me a better understanding of the current theories surrounding invisibility. This will include research into current prototypes from invisibility cloaks from visible and non-visible light, what metamaterials have been used in these prototypes and the mathematics behind the invisibility. This should provide a basis for the model.

There will also need to be research into what programming language to use and any libraries that will need to learn for that programming language. This will also affect my decision on which type of global illumination technique to use. As the idea of multiple models is still dependant on the amount of time it takes to create one model and test it adequately, choosing one global illumination strategy now will give me a solid goal for my first model. Both of these will require some time to research and become familiar with, depending on whether or not I have previous experience.

Next will need to be a design of the cloak and tests needed based on previous research. This will include the necessary algorithms and formulas for the model, tests for the model, as well the various features that will be implemented.

Then the model will be implemented based on the design created. Depending on the amount of time it takes to complete these steps, multiple models may be created for contrast and comparison. These will all be tested and the results noted down for the final report.

3. Project deliverables

- Model(s) of invisibility cloak which will be implemented in the programming language chosen.

- Results of experiments and tests on model(s) in table format and linking to tests specified in the test specification.
- Design specification created using research
- Test specification including tests for robustness as well as experiments checking for limitations and strengths of the cloak.
- Final report
- Blog for progress tracking that will include links to current versions of program and any research undertaken with references to research.

4. Initial annotated bibliography

[1] U. Leonhardt and T. G. Philbin, "Chapter 2 Transformation Optics and the Geometry of Light," *Prog. Opt.*, vol. 53, pp. 69–152, May 2009.

This paper explains extremely clearly the mathmatics and theory behind transformation optics, which is the basis for invisibility research.

[2] D. Schurig, J. J. Mock, B. J. Justice, S. a Cummer, J. B. Pendry, a F. Starr, and D. R. Smith, "Metamaterial electromagnetic cloak at microwave frequencies.," *Science*, vol. 314, no. 5801, pp. 977–980, 2006.

This is a paper discussing an electromagnetic invisiblity cloak that hides objects from microwaves. The paper has been useful in outlining the type of structure the model might take, based on the kind of structure used in the metamaterial.

[3] J. B. Pendry, *Metamaterials and the Science of Invisibility*. London, UK: Youtube, 2013.

A lecture given by a leading expert in the field of metamaterials and invisiblity research. It explains the history of the subject, current advances in the field and the general theories, as well as projects he has worked on.