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**AN INVESTIGATION INTO THE USE OF OPENGL  
AS A LIBRARY FOR THE SIMULATION OF  
INFRARED SCENARIOS**

by

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Submitted in partial fulfillment of the requirements for the degree

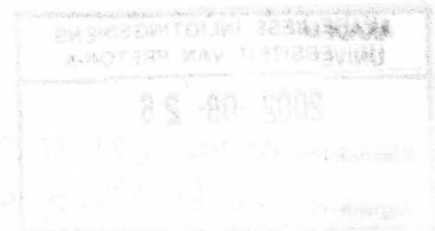
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In the beginning God created the heaven and the earth.  
And the earth was without form, and void; and darkness was upon the face of  
the deep. And the Spirit of God moved upon the face of the waters.  
And God said, Let there be light: and there was light.  
And God saw the light, that it was good: and God divided the light from the  
darkness.  
And God called the light Day, and the darkness he called Night. And the evening  
and the morning were the first day.

*Genesis 1:1-5*

Now to him who is able to do immeasurably more than all we ask or imagine,  
according to his power that is at work within us,  
to him be glory in the church and in Christ Jesus throughout all generations, for  
ever and ever! Amen.

*Ephesians 3:20-21*



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## Summary

The generation of real-time infrared imagery was previously the domain of multi-million rand graphics supercomputers such as the SGI Onyx2. The purpose of this study is to investigate the implementation of radiometrically accurate infrared simulations on a personal computer, by adapting the widely available graphics library, OpenGL®.

An introduction is given into the radiometric and computer graphics principles related to this study. A technique is investigated to increase the dynamic range that is available in commercial graphics accelerators. It is shown that it is possible to map spectrally variant radiometric quantities to equivalent single-parameter variables that can be used in infrared simulations, bearing in mind certain constraints. The implementation of an infrared simulation shows that the current generation PC hardware can render images at real-time frame rates, but that extra processing is required to generate radiometrically accurate images at the required frame rates.

**Keywords:** OpenGL, infrared simulations, real-time scene generation, radiometric parameters, atmospheric transmittance, path radiance.

## Opsomming

Die intydse berekening van infrarooi beelde het voorheen 'n grafika superrekenaar soos die SGI Onyx2 benodig. Die doelwit van hierdie studie is om die implementering van radiometries akkurate infrarooi simulaties op 'n persoonlike rekenaar te ondersoek. OpenGL®, 'n algemeen beskikbare grafika biblioteek, word aangepas om hierdie simulaties te kan doen.

'n Oorsig word gegee van die radiometrie en rekenaargrafika wat betrekking het op hierdie studie. 'n Tegniek word ondersoek om die dinamiese bereik van kommersiële skermkaarte te verhoog. Daar word aangetoon dat dit moontlik is om spektrale radiometriese veranderlikes met enkel-parameter veranderlikes voor te stel indien daar aan sekere beperkings voldoen word. 'n Implementering van 'n simulatie toon aan dat huidige generasie persoonlike rekenaars wel die beelde teen intydse raamtempos kan genereer, maar dat ekstra prosessering nodig is om radiometries akkurate beelde te genereer.

**Sleutelwoorde:** OpenGL, infrarooi simulaties, intydse beeld generasie, radiometriese parameters, atmosferiese transmittansie, padradiansie.

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## List of Abbreviations and Symbols

|           |   |
|-----------|---|
| API       | Application programming interface   |
| ARB       | Architectural review board  |
| AUX       | OpenGL <i>auxiliary</i> library   |
| COTS      | Commercial-off-the-shelf  |
| CPU       | Central processing unit   |
| CRT       | Cathode ray tube  |
| DMA       | Direct memory access  |
| FLIR      | Forward looking infrared - a thermal imager                                 |
| GUI       | Graphical user interface  |
| OpenGL    | Open graphics library. It is a trademark of SGI                             |
| PC        | Personal computer - typically using an Intel processor                      |
| SGI       | Trade name of the company previously trading as Silicon Graphics Inc.       |
| $\alpha$  | Absorptivity. It is also used for the atmospheric transmittance coefficient |
| $c$       | Speed of light in $ms^{-1}$   |
| $E$       | Irradiance in $Wm^{-2}$   |
| $h$       | Planck's constant in $Js$   |
| $I$       | Intensity in $Wsr^{-1}$   |
| $k$       | Boltzmann constant in $JK^{-1}$   |
| $\lambda$ | Wavelength  |
| $L$       | Radiance in $Wm^{-2}sr^{-1}$  |
| $M$       | Exitance in $Wm^{-2}$   |
| $\Omega$  | Solid Angle   |
| $\Phi$    | Radiant flux in $W$   |
| $\rho$    | Reflectivity  |
| $\tau$    | Transmissivity  |
| $T$       | Temperature   |