UNIVERSITY OF COPENHAGEN
DEPARTMENT OF COMPUTER SCIENCE

# Implicit-based collision detection

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## Motivation

Collision detection may be utilized in multiple ways, two of which are of special interest to us:

- Physics-based simulations
- Collision-based registration

In order to serve both needs, we develop a plug-in collision detection algorithm.

## Methods

### Signed distance fields

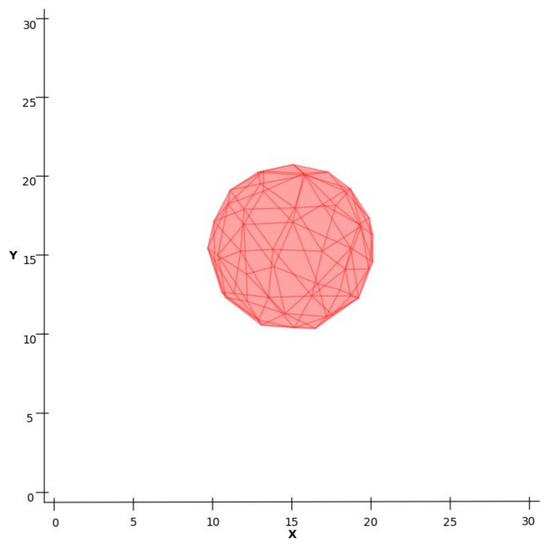
Geometrical objects may be represented explicitly, e.g. as triangle meshes, as well as with implicit surface functions.
One type of implicit functions is called signed distance fields. They are defined as:

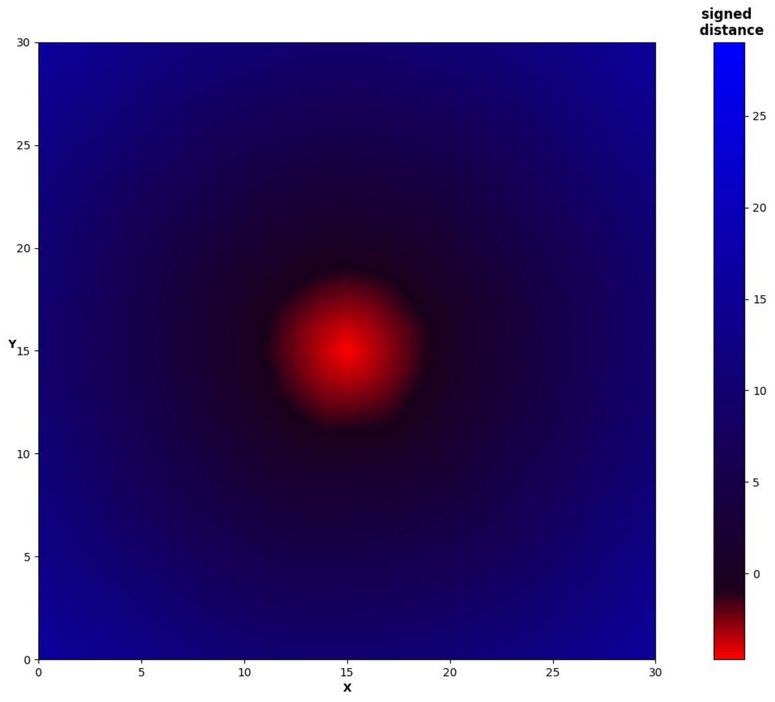
$$\Phi(\vec{x}) = \begin{cases} d(\vec{x}) & if,\ \vec{x} \in \Omega^{+} \\ d(\vec{x}) = 0 & if,\ \vec{x} \in \partial\Omega \\ -d(\vec{x}) & if,\ \vec{x} \in \Omega^{-} \end{cases} \quad (1)$$

with

$$d(\vec{x}) = min(|\vec{x} - \vec{x}_I|)$$
$$where\ \vec{x}_I \in \partial\Omega$$

as the metric function.

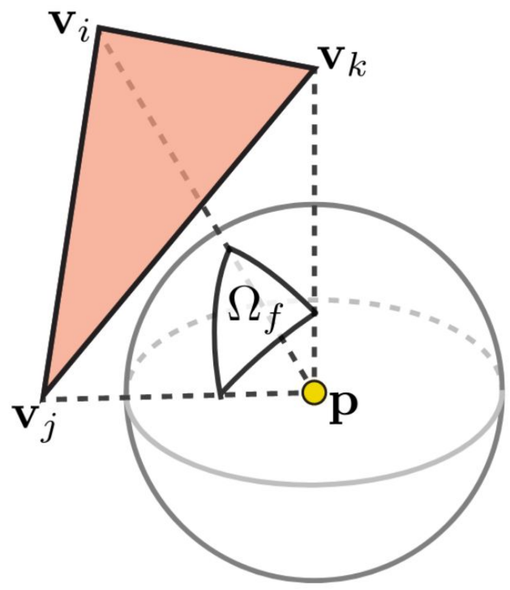



**Signed distance field of a sphere**

### Winding numbers

We generate the signed distance field by using the winding number algorithm. The winding number itself is the sum of all solid angles. A solid angle represents the area of each triangle projected onto the unit sphere. A winding number equal to the unit sphere surface area indicates an interior point position.

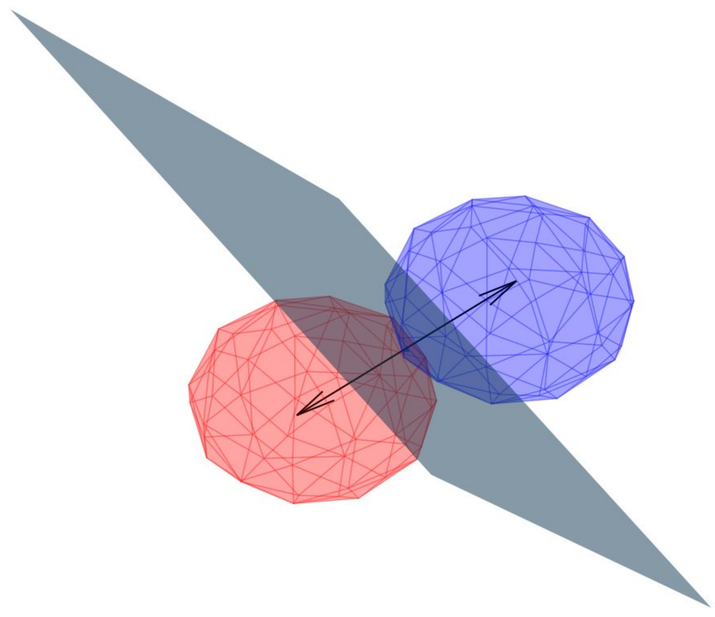



**Example of solid angle**

A. Jacobson, L. Kavan, O. Sorkine-Hornung.

### Collision detection

The collision detection algorithm is divided into three parts. The first step is a case distinction with bounding volumes. The second step consists of a gradient descent in barycentric coordinates over the signed distance field. Last, in case of a collision, the contact point and contact plane are generated.



**Collision detection with contact point and contact plane generation**

## Future work

The next steps are the implementation of a deformation mapping a well as an application to affine registration.

## References

A. Jacobson, L. Kavan, O. Sorkine-Hornung. “Robust Inside-Outside Segmentation using Generalized Winding Numbers”. ACM Transactions on Graphics 32 (4), July 2013.
C. Ericson. “Real-time Collision Detection”. Elsevier, 2005.

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