Microfacet-Based Normal Mapping
for Robust Monte Carlo Path Tracing

Mitsuba Plugins

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1 Installation

We provide 5 plugins for Mitsuba:

- **normalmap_microfacet_default** implements the analytic 2nd-order scattering for the specular tangent-facet model that we recommend using by default.

- **normalmap_microfacet** implements the general model presented in the paper, which is based on a random-walk approach and comes with additional appearance parameters.

- **normalmap_flip** implements a standard practice in the industry which we provide for comparison: it flips the direction of the shading normal. In this way, directions always are in the positive hemisphere of the shading normal and no directions are undefined.

- **normalmap_switch** implements another standard practice in the industry which we provide for comparison: it switches to an alternative BRDF for undefined directions. It requires an arbitray choice of this alternative BRDF. We use a diffuse BRDF with albedo = 0:5.

- **normalmap_microfacet_nonseparable** implements the alternative microfacet model with non-separable masking-shadowing presented in a supplemental material.

Copy the files in the repository `.\mitsuba\src\bsdf\` which is also the location of Mitsuba's plugin **normalmap**. Reference the plugin in the configuration file and recompile Mitsuba.

2 XML Scene Description

2.1 Classic Normal Mapping

Mitsuba provides a plugin **normalmap** by default that takes as input a BRDF and a normal map texture. Its specification is shown in Listing 1.

```
<bsdf type="normalmap"> <!--classic normal mapping-->
    <bsdf type="roughconductor">
        <float name="alpha" value="0.1"/>
        <string name="distribution" value="ggx"/>
        <string name="material" value="Au"/>
    </bsdf>
    <texture name="normals" type="bitmap">
        <string name="filename" value="normals.png"/>
        <float name="gamma" value="1.0"/>
    </texture>
</bsdf>
```

Listing 1: *The Mitsuba scene description with classic normal mapping.*

2.2 Microfacet-Based Normal Mapping: Default

Our default plugin **normalmap_microfacet_default** can be used as a direct replacement of **normalmap**, as shown in Listing 2.

```xml
<bsdf type="normalmap_microfacet_default">
    <bsdf type="roughconductor">
        <float name="alpha" value="0.1"/>
        <string name="distribution" value="ggx"/>
        <string name="material" value="Au"/>
    </bsdf>
    <texture name="normals" type="bitmap">
        <string name="filename" value="normals.png"/>
        <float name="gamma" value="1.0"/>
    </texture>
</bsdf>
```

Listing 2: *The Mitsuba scene description with microfacet-based normal mapping by default.*

2.3 Microfacet-Based Normal Mapping: Options

Our plugin **normalmap_microfacet** implements all the options proposed in the paper. It coms with additional appearance parameters shown in Listing 3:

- **saturation** ranges from 0 to 1 and blends the same-material model of Section 6.1 (saturation = 1) and the specular-material model of Section 6.2. If not provided explicitly, its default value is 0 (specular-material).

- **maxScatteringOrder** ranges from 0 to ∞ and controls the maximal order of multiple-scattering (fractional values are possible). If not provided explicitly, its default value is 2.

```xml
<bsdf type="normalmap_microfacet">
    <bsdf type="roughconductor">
        <float name="alpha" value="0.1"/>
        <string name="distribution" value="ggx"/>
        <string name="material" value="Au"/>
    </bsdf>
    <texture name="normals" type="bitmap">
        <string name="filename" value="normals.png"/>
        <float name="gamma" value="1.0"/>
    </texture>

    <!--optional appearance parameters-->
    <float name="saturation" value="0.0"/>
    <float name="maxScatteringOrder" value="'.0"/>
</bsdf>
```

Listing 3: *The Mitsuba scene description with microfacet-based normal mapping with optional appearance parameters.*

3 Additional Mitsuba Results

We set these materials for the following results:

```
1  <bsdf type="normalmap">
       <bsdf type="roughconductor">
3          <float name="alpha" value="0.01"/>
           <string name="distribution" value="ggx"/>
5          <string name="material" value="none"/>
       </bsdf>
7      <texture name="normals" type="bitmap">
           <string name="filename" value="normals.png"/>
9          <float name="gamma" value="1.0"/>
       </texture>
11 </bsdf>
```
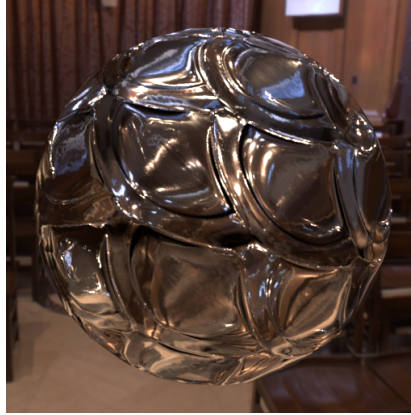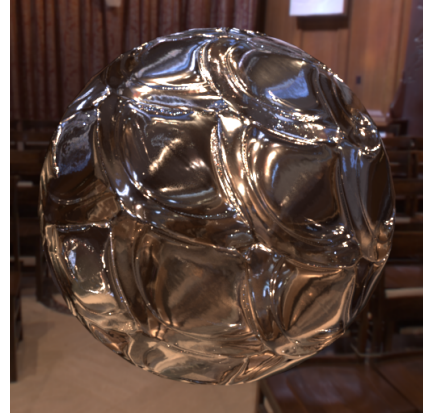
Listing 4: *A white GGX conductor of roughness $\alpha = 0.01$.*

```
1  <bsdf type="normalmap">
       <bsdf type="roughconductor">
3          <float name="alpha" value="0.1"/>
           <string name="distribution" value="ggx"/>
5          <string name="material" value="Au"/>
       </bsdf>
7      <texture name="normals" type="bitmap">
           <string name="filename" value="normals.png"/>
9          <float name="gamma" value="1.0"/>
       </texture>
11 </bsdf>
```

Listing 5: *A gold GGX conductor of roughness $\alpha = 0.1$.*

```
1  <bsdf type="normalmap">
       <bsdf type="roughconductor">
3          <float name="alpha" value="0.3"/>
           <string name="distribution" value="ggx"/>
5          <string name="material" value="Cu"/>
       </bsdf>
7      <texture name="normals" type="bitmap">
           <string name="filename" value="normals.png"/>
9          <float name="gamma" value="1.0"/>
       </texture>
11 </bsdf>
```

Listing 6: *A copper GGX conductor of roughness $\alpha = 0.3$.*

normalmap
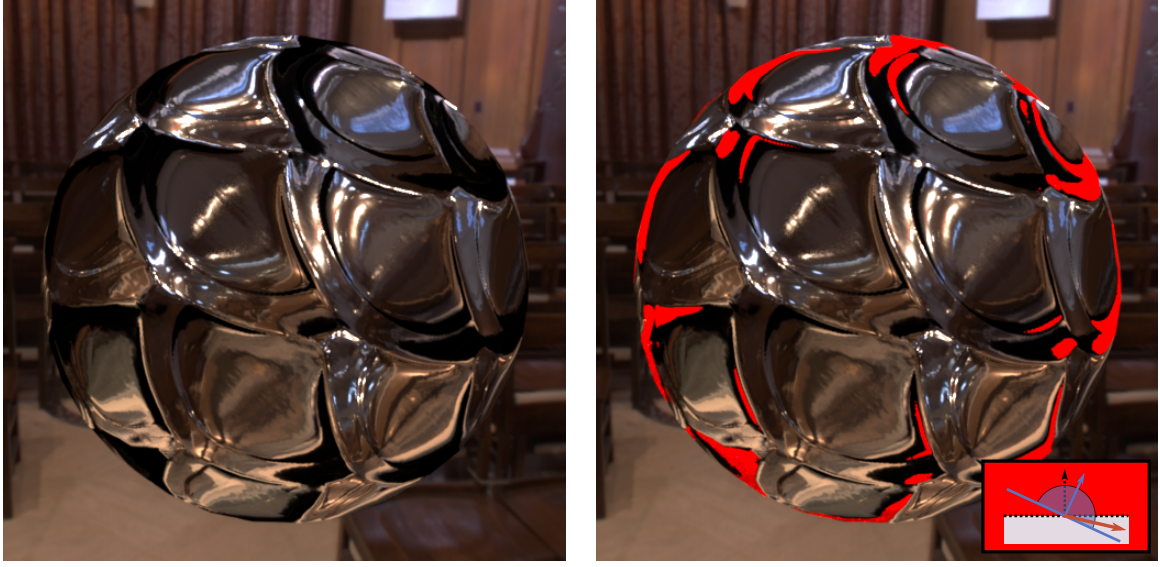
normalmap_microfacet
saturation=0, maxScatteringOrder=1
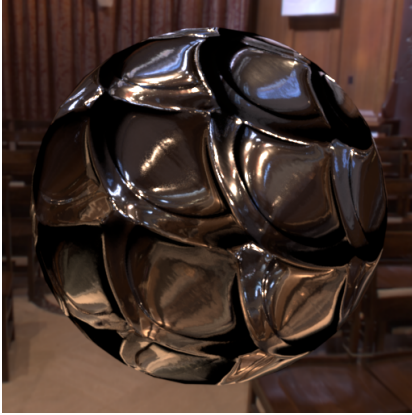
normalmap_microfacet
saturation=0, maxScatteringOrder=2
= normalmap_microfacet_default

normalmap_microfacet
saturation=0, maxScatteringOrder=4

normalmap_microfacet
saturation=1, maxScatteringOrder=1

normalmap_microfacet
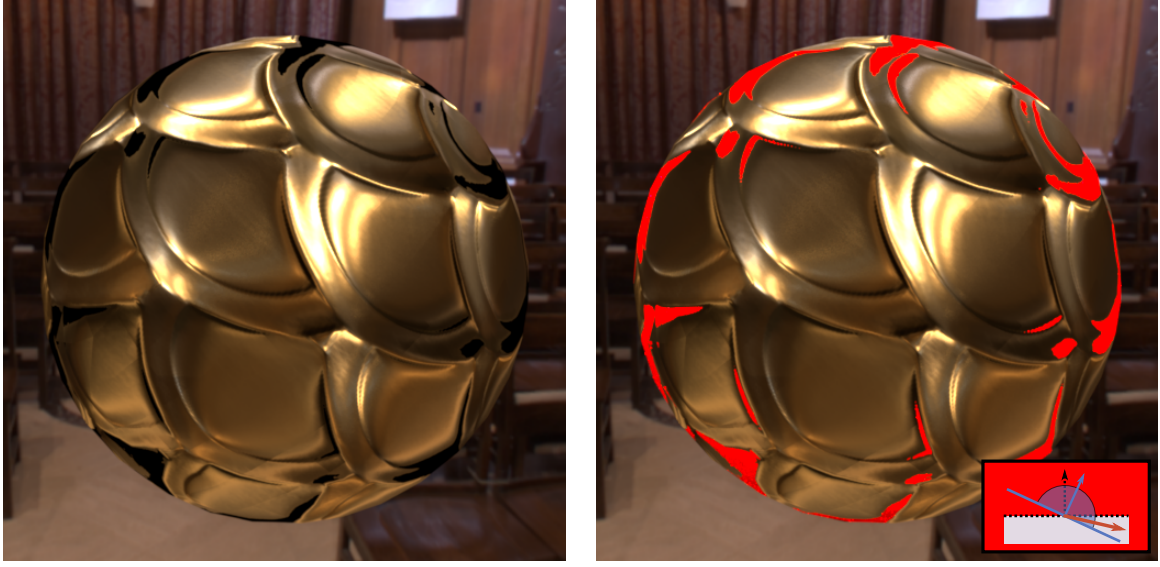saturation=1, maxScatteringOrder=2

normalmap_microfacet
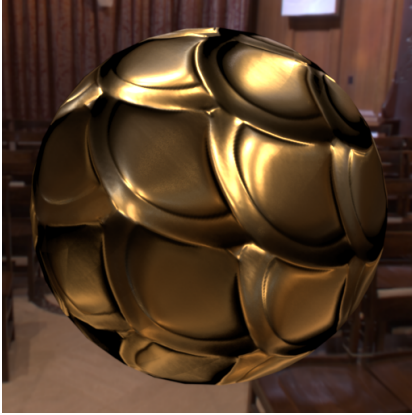saturation=1, maxScatteringOrder=4
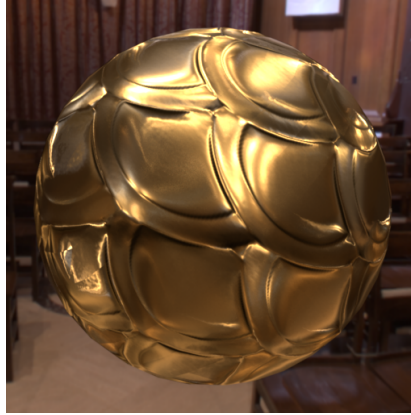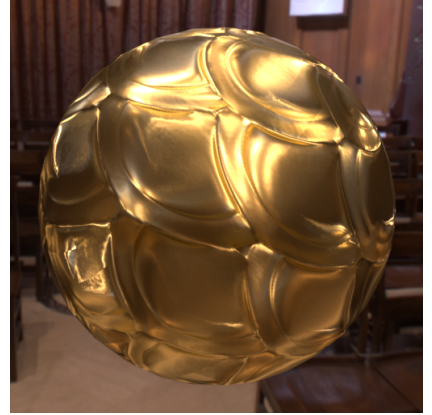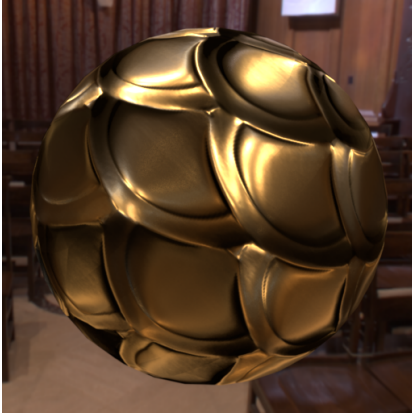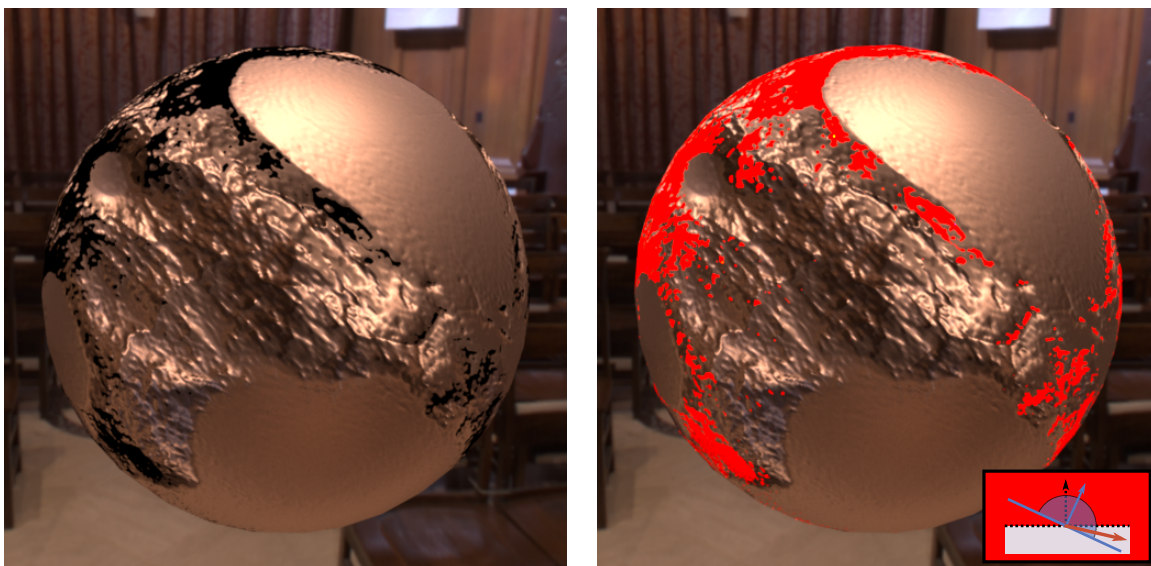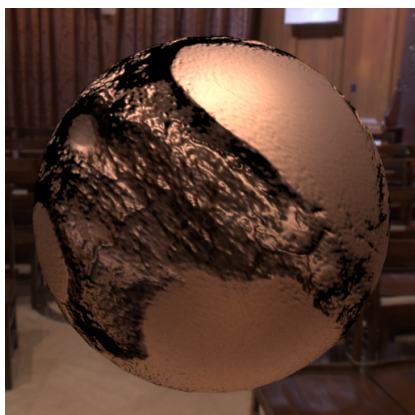
Figure 1: A white GGX conductor of roughness $\alpha = 0.01$.

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normalmap

normalmap_microfacet
saturation=0, maxScatteringOrder=1

normalmap_microfacet
saturation=0, maxScatteringOrder=2
= normalmap_microfacet_default

normalmap_microfacet
saturation=0, maxScatteringOrder=4

normalmap_microfacet
saturation=1, maxScatteringOrder=1

normalmap_microfacet
saturation=1, maxScatteringOrder=2

normalmap_microfacet
saturation=1, maxScatteringOrder=4

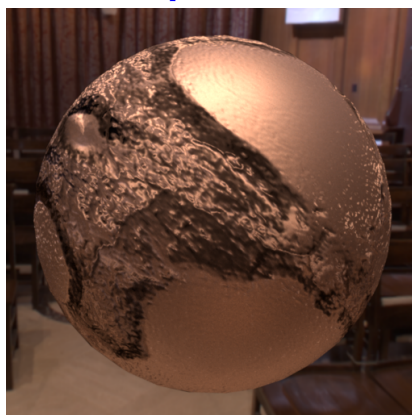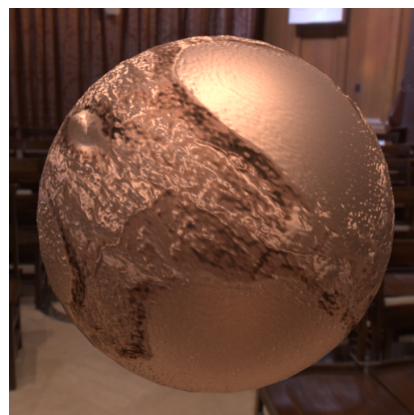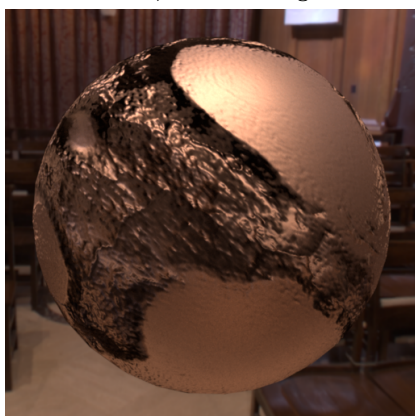Figure 2: A gold GGX conductor of roughness $\alpha = 0.1$.

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normalmap

normalmap_microfacet
saturation=0, maxScatteringOrder=1

normalmap_microfacet
saturation=0, maxScatteringOrder=2
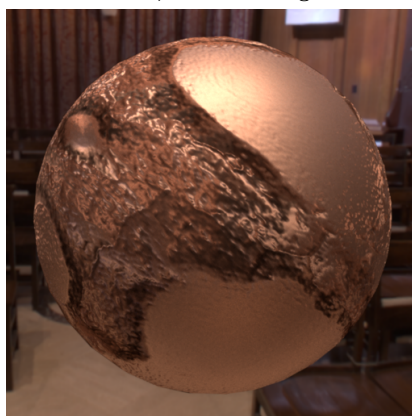= normalmap_microfacet_default

normalmap_microfacet
saturation=0, maxScatteringOrder=4

normalmap_microfacet
saturation=1, maxScatteringOrder=1

normalmap_microfacet
saturation=1, maxScatteringOrder=2
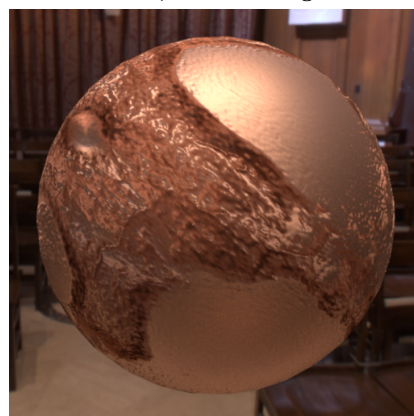
normalmap_microfacet
saturation=1, maxScatteringOrder=4

Figure 3: A copy GGX conductor of roughness $\alpha = 0.3$.