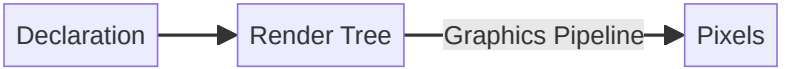
Immediate Mode Rendering Pattern

Who: Erik

Product: HeavyGoods.net

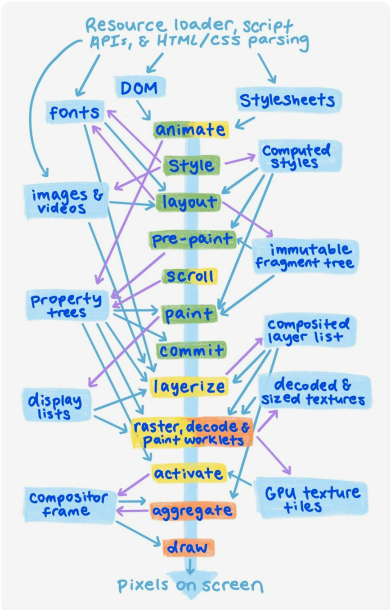
Lang: Typescript

Rendering (with a pipeline) 1



Rendering (with a pipeline) 2

Rendering (with a pipeline) 3

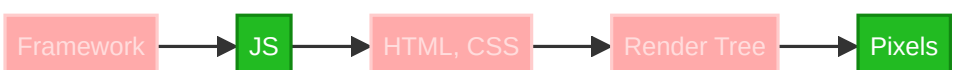

Resource loader, script APIs, & HTML/CSS parsing
DOM
Stylesheets
fonts
animate
Style
Computed styles
images & videos
layout
pre-paint
immutable fragment tree
scroll
property trees
paint
composited layer list
commit
layerize
decoded & sized textures
display lists
raster, decode & paint worklets
activate
compositor frame
aggregate
GPU texture tiles
draw
Pixels on screen

Oh No

- everything is sooo complex 🤯
- what if we're tasked creating the pixels ourselves?

Imagine we're the new Luddites:

to the rescue: "Immediate mode"



Immediate Mode Code

```
document.body.innerHTML = '<canvas style="background-color: white" />';

const canvas = document.getElementsByTagName("canvas")[0];
const ctx = canvas.getContext("2d");
```

```
ctx.strokeRect(1, 1, 100, 20);
ctx.fillText("OK", 30, 15);
```

```
canvas.onclick = ({ offsetX, offsetY }) => {
  if (offsetX > 1 && offsetX < 100 && offsetY > 1 && offsetY < 20) {
    console.log("click");
  }
};
```

Immediate Mode Code

State change

```
const state = { ok: true };
```

```
setInterval(
  () => {
    ctx.clearRect(0, 0, canvas.width, canvas.height);
    ctx.strokeRect(1, 1, 100, 20);
    ctx.fillText(state.ok ? "OK" : "NOT OK", 30, 15);
  },
  (1 / 60) * 1000, // 60Hz
);
```

```
canvas.onclick = ({ offsetX, offsetY }) => {
  if (offsetX > 1 && offsetX < 100 && offsetY > 1 && offsetY < 20) {
    state.ok = !state.ok;
  }
};
```

State change

Nesting

```
const state = { ok: [true, true, false] };
```

```
setInterval(
  () ⇒ {
    ctx.clearRect(0, 0, canvas.width, canvas.height);
    for (const i of [0, 1, 2]) {
      ctx.strokeRect(1, 1 + 25 * i, 100, 20);
      ctx.fillText(state.ok[i] ? "OK" : "NOT OK", 30, 15 + 25 * i);
    }
  },
  (1 / 60) * 1000, // 60Hz
);
```

```
canvas.onclick = ({ offsetX, offset… ⇒ { … }
```

Functional 💕 Programming

```
function button(env, { x, y, width, height, label, onclick }) {
  env.ctx.strokeRect(x, y, width, height);
  env.ctx.fillText(label, x + 30, y + 15);

  env.onclick.push(({ offsetX, offsetY }) => {
    if (
      offsetX > x &&
      offsetX < x + width &&
      offsetY > y &&
      offsetY < y + height
    ) {
      onclick();
    }
  });
}
```

FP 💕 - Container

```
function stackLayout(env, { children, height }) {
  let y = 1;

  for (let i = 0; i < children.length; i++) {
    const c = children[i];

    c(env, { y });

    y += height;
  }
}
```

FP 💕 - Composition

```
function root(env) {
  stackLayout(env, {
    height: 30,
    children: [0, 1, 2].map(
      (i) ⇒
        (env, { y }) ⇒
          button(env, {
            x: 1,
            y,
            width: 100,
            height: 20,
            label: state.ok[i] ? `OK ${i}` : `NOT OK ${i}`,
            onclick: () ⇒ {
              state.ok[i] = !state.ok[i];
            },
          }),
    ),
  });
}
```

FP 💕 - render1

```
function render1(canvas, root) {
  const onclick = [];
  const ctx = canvas.getContext("2d");

  ctx.clearRect(0, 0, canvas.width, canvas.height);

  root({ ctx, onclick });

  canvas.onclick = (ev) => onclick.forEach((c) => c(ev));
}
```

FP 💕 - Loop

```
let state = {ok: [true, true, false]}

setInterval(
    () ⇒ {
      render1(canvas, root);
    },
    (1 / 60) * 1000, // 60Hz
  );
```

FP 💕

Why?

⊕⊕⊕

- no invisible steps
- render trees live inside the stack
- simple implementation (few lines of code)
- simple to use and debug (looks like react)
- extreme control over the output (pixel perfect)
- works on any system

⊖⊖⊖

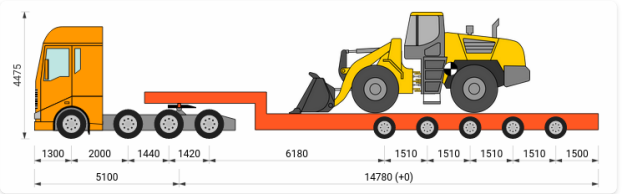
- computationally expensive (aka inefficient): renders everything all the time
- not standardized
- hard with layouts that require to know the size of some parts

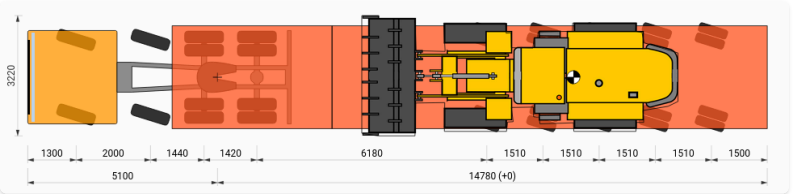
Conclusion

- it can be done
- don’t be afraid
- easily doable with basic FP- or OOP-skills (no endofunctors nor decorators required)

Anyone want to see it real life?

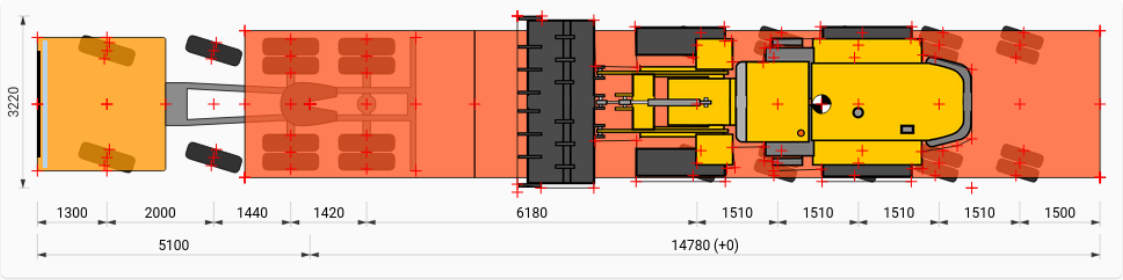
We use it in heavygoods.net to build simple vector-like vehicle depictions:



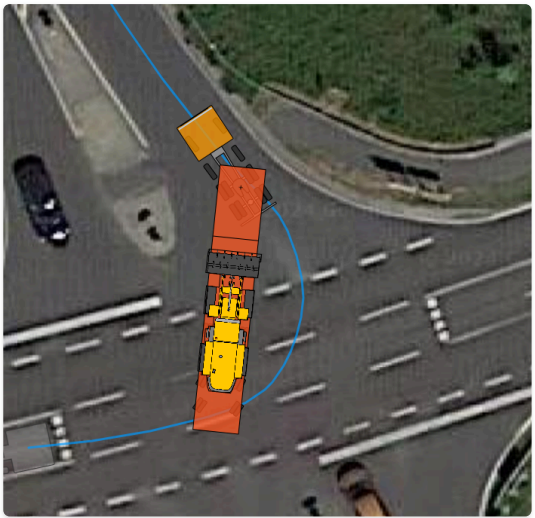


RL - debugging

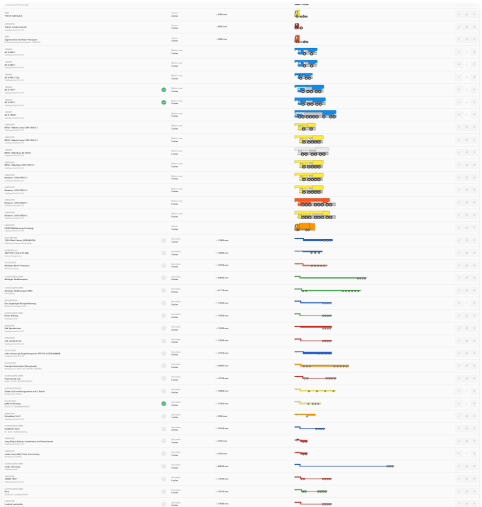
With key points highlighted for debugging:



RL - full scene



RL - in a table



Implementation - Feats

Some tricks were necessary to make it work:

- DX: explicit `2D` transformation matrix to group nested components
- DX: `ctx` is a facade to allow different render backends: svg, canvas, points, bounds
- DX: backends allow easy layouting
- DX: drawings have become models that contain truths (e.g. length of a vehicle is its drawing bounds 😲)
- PERF: svg has a flat "virtual dom" for fast rerendering while dragging elements

Implementation - Actual Code

```
export function semiTrailerTop(
  trailer: SemiTrailer | JointSemiTrailer,
  vehicleState?: SimulationVehicleState,
): Shape {
  /* defines axles, virtualAxleShape, chassis */

  return group({
    children: [
      ref({ key: "origin" }),
      ref({ key: "chassisFrontJoint", pos: [0, 0] }),
      axles,
      virtualAxleShape,
      chassis,
    ],
  });
}
```

Thats all

Thanks!

Special Thanks: check out https://sli.dev - best tool so far to build slide decks with.

- built in diagrams with https://mermaid.js.org/
- built in code highlighting (& editing)
- my running examples are just vue components
- runs in github docs and exports to pdf