Semisimplicial Types in Internal CwFs

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Semisimplicial Types

A *semisimplicial type* is a semisimplicial object in “the” category of types.

Presented by:

$$
\begin{aligned}
A_0 &: \mathsf{Type} \\
A_1 &: A_0 \times A_0 \to \mathsf{Type} \\
A_2 &: \left(\textstyle\sum_{x,\, y,\, z : A_0} A_1(x, y) \times A_1(x, z) \times A_1(y, z)\right) \to \mathsf{Type} \\
&\ \vdots \\
A_n &: \partial\Delta^n(A_0, \ldots, A_{n-1}) \to \mathsf{Type} \\
&\ \vdots
\end{aligned}
$$

Semisimplicial Types

Why? [Kra18]

- Building block for homotopical/higher categorical structures. [KS17; CK17; Kra21]
- Example of higher coherence we don't know how to internalize.

  This is okay:

$$\mathsf{SST}(n) :\equiv \text{type of tuples } (A_0, \ldots, A_n)$$

  [Bru; Kra14]

Open question

Define

$$\mathsf{SST} : \mathbb{N} \to \mathsf{Type}_1$$

in HoTT. *Can we construct semisimplicial types?* [Her15; ACK16]

HoTT in HoTT

Open question

Define the syntax of HoTT in HoTT together with interpretations into itself. *Can HoTT eat itself?* [Shu14; EX14; Buc17]

Theorem (expected)

If HoTT can eat itself then we can construct semisimplicial types.

Set-Based Internal CwFs

An *internal CwF* $\mathcal{C}$ is a category with families [Dyb95] internal to HoTT. Consists of

$$
\begin{aligned}
\mathsf{Con} &: \mathsf{Type} \\
\mathsf{Sub} &: \mathsf{Con} \to \mathsf{Con} \to \mathsf{Type} \\
\mathsf{Ty} &: \mathsf{Con} \to \mathsf{Type} \\
\mathsf{Tm} &: (\Gamma : \mathsf{Con}) \to \mathsf{Ty}\,\Gamma \to \mathsf{Type} \\
&\vdots
\end{aligned}
$$

$\mathcal{C}$ is *set-based* if Con, Sub, Ty, Tm are h-sets.

SST in Internal CwFs

Current work in progress

Construct semisimplicial types in set-based internal CwFs $\mathcal{C}$ with $\hat{\Pi}$, $\hat{\Sigma}$ and U (and $\mathbb{1}$?). i.e. Define

$$\mathsf{SST}_{\mathcal{C}} : \mathbb{N} \to \mathsf{Con}$$

where $\mathsf{SST}_{\mathcal{C}}\, n$ is the context

$$A_0 : U,\ A_1 : A_0 \mathbin{\hat{\times}} A_0 \mathbin{\hat{\to}} U,\ \ldots,\ A_n : \partial\Delta^n \mathbin{\hat{\to}} U$$

Technicalities

Sketch of construction:

Assume set-based internal CwF $\mathcal{C} = (\mathsf{Con}, \mathsf{Sub}, \mathsf{Ty}, \mathsf{Tm}, \hat{\Pi}, \hat{\Sigma}, U, \dots)$. Define

$$\mathsf{SST} : \mathbb{N} \to \mathsf{Con} \qquad \dots \; \mathsf{SST}_{k+2} :\equiv \mathsf{SST}_{k+1}, \underbrace{\mathsf{Sk}_{(k+2,\,\dots)} \mathbin{\hat{\to}} U}_{\text{Fillers}}$$

mutually with

$$\mathsf{Sk} : (b, h, t : \mathbb{N}) \to \mathsf{Ty}\,(\mathsf{SST}_{h+1}) \qquad \dots \; \mathsf{Sk}_{(b,\,h,\,t+1)} :\equiv \widehat{\sum}_{x :\, \mathsf{Sk}_{(b,h,t)}} \underbrace{A_{h+1}\,(\mathsf{Skm}\,(\dots, x))}_{\text{Fill the } (t+1)^{\text{th}} \text{ face}}$$

and

$$\begin{aligned} \mathsf{Skm} : &\{b, h, t, k : \mathbb{N}\} \\ &\to (f : \Delta_+(k, b)) \\ &\to \mathsf{Tm}\left(\mathsf{Sk}_{(b,h,t)}\right) \to \mathsf{Tm}\left(\mathsf{Sk}_{(b,h,t)\cap f}\right) \end{aligned}$$

SST in Internal CwFs

Theorem (expected)

If HoTT can eat itself then we can construct semisimplicial types.

Proof.

An interpretation of the syntax of (HoTT + a universe) as an internal set-based CwF $\mathcal{C}$ gives

$$\mathsf{HoTT\text{-}Con} : \mathsf{Con} \to \mathsf{Type}_1.$$

Then we have

$$\mathsf{SST} :\equiv \mathsf{HoTT\text{-}Con} \circ \mathsf{SST}_{\mathcal{C}} : \mathbb{N} \to \mathsf{Type}_1.$$

$\square$

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