NOTE ON TYPE THEORIES

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[Cis19]

Notation 0.1. We employ the following notations.

- (2,1)-categories are denoted by bf symbols: $\mathbf{C}, \mathbf{A}, \mathbf{E}, \ldots$ or bb symbols: $\mathbb{I}, \mathbb{D}, \mathbb{A}, \ldots$
- $\mathbf{Set}$ is the category of sets.
- $\mathbf{Cat}$ is the large (2,1)-category of categories.
- There is a fully faithful (2,1)-functor $\mathtt{disc}\colon \mathbf{Set} \hookrightarrow \mathbf{Cat}$.
- $\mathfrak{C}at$ is the large 2-category of categories.
- Δ^1 is the 1-simplex seen as a category. $\mathbf{C}^{\Delta^1}$ is the arrow category of $\mathbf{C}$.
- $\mathbf{C}_{/A}$ and $\mathbf{C}_{A/}$ are over and under categories respectively.
- $\mathtt{cod}$ and $\mathtt{dom}$ mean codomain and domain respectively. They often have as their type $\mathbf{C}^{\Delta^1} \longrightarrow \mathbf{C}$, $\mathbf{C}_{/A} \longrightarrow \mathbf{C}$, or $\mathbf{C}_{A/} \longrightarrow \mathbf{C}$.
- By a ***replete class of morphisms*** of $\mathbf{C}$, we mean a replete fullsubcategory of $\mathbf{C}^{\Delta^1}$.
- $\mathbf{WSub}$ is the replete full sub (2,1)-category of $\mathbf{Cat}^{\Delta^1}$ consisting of wide subcategory inclusions; i.e., faithful functors that induce equivalences on core groupoids.
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Definition 0.2. A ***display map category*** $\mathbf{C} = (\mathbf{C}, \mathsf{Dis})$ is a pair of a category $\mathbf{C}$ and a replete class Dis of morphisms satisfying the following conditions. Arrows in Dis are called ***display maps*** of $\mathbf{C}$.

- $\mathbf{C}$ has a terminal object.
- Let $h\colon A \longrightarrow B$ and $f\colon X \twoheadrightarrow B$ be morphisms in $\mathbf{C}$ such that f is a display map. Then there is a pullback square
$$\begin{tikzcd} \cdot \arrow[r] \arrow[d, two heads] \arrow[dr, phantom, "\lrcorner", very near start] & X \arrow[d, two heads, "f"] \\ A \arrow[r, "h"'] & B \end{tikzcd}$$
in $\mathbf{C}$ such that the left side is also a display map. ■

Definition 0.3. A ***clan*** $\mathbf{C} = (\mathbf{C}, \mathsf{Fib})$ is a display map category satisfying the following conditions. Display maps (i.e., arrows in Fib) are called ***fibrations*** of $\mathbf{C}$.

- For each object $A \in \mathbf{C}$, the unique morphism $A \longrightarrow 1$ towards the terminal object is a fibraion.
- Fib is closed under composition. ■

Definition 0.4. A ***representable map category*** $\mathbf{R} = (\mathbf{R}, \mathsf{Rep})$ is a display map category satisfying the following conditions. Display maps (i.e., arrows in Rep) are called ***representable maps*** of $\mathbf{R}$.

- $\mathbf{R}$ is finitely complete.
- For each representable map $f\colon X \twoheadrightarrow Y$, the pullback functor $f^*\colon \mathbf{R}_{/Y} \longrightarrow \mathbf{R}_{/X}$ has a right adjoint f_*. ■

Definition 0.5. A ***strict category*** is a category equipped with its wide subcategory that is a set. In other words, the (2,1)-category $\mathbf{StrCat}$ of strict categories is defined by the following pullback square.

$$\begin{tikzcd} \mathbf{StrCat} \arrow[r] \arrow[dd, "\mathsf{Obj}"'] \arrow[dr, phantom, "\lrcorner", very near start] & \mathbf{WSub} \arrow[d, hook] \\ & \mathbf{Cat}^{\Delta^1} \arrow[d, "\mathtt{dom}"] \\ \mathbf{Set} \arrow[r, "\mathtt{disc}"'] & \mathbf{Cat} \end{tikzcd}$$

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The functor on the left is locally fully faithful and surjective on objects. In particular, **StrCat** is a category. ■

Definition 0.6. A ***contextual category*** $\mathbf{C} = (\mathbf{C}, \mathsf{Dis}, (), \ell)$ consists of the following data.

- A strict category $\mathbf{C}$.
- A structure Dis of a display map category for the underlying category of $\mathbf{C}$.
- An object $()$ of $\mathbf{C}$ which is a terminal object in the underlying category of $\mathbf{C}$.
- A function $\ell\colon \mathsf{Obj}(\mathbf{C}) \longrightarrow \mathbb{N}$ satisfying the following conditions.
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Theorem 0.7. shoumei no aidani claim ireru yatu ◆

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References

[Cis19] D.-C. Cisinski. *Higher Categories and Homotopical Algebra*, volume 180 of *Cambridge Studies in Advanced Mathematics*. Cambridge University Press, Cambridge, 2019. doi:10.1017/9781108588737.

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