Rich types, Tractable typing – Overview –

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What have you learnt for now?

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$$\boxed{\text{Well typed programs never go wrong!}}$$

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What have you learnt for now?

Well typed programs never go wrong!

A precise account on key concepts behind this slogan

- Typed functional programming
- Operational semantics
- Type soundness

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The slogan is a bit strong, isn't it?

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```
List.map2 ( / ) l1 l2
```

Type safety, more precisely

Type safety is **a deal between the type system and the runtime**: to be safe, the well-formedness of each term must be checked.

There are **implicit assumptions** about which of these checks are the responsability of the typechecker and which part is the responsability of the runtime system.

Of course, we prefer static checks: they improve both the robustness and the performance of our programs! But how far can we go? Can we totally remove the aforementionned implicit assumptions?

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Richer types, richer guarantees

```
List.map2 ( / ) l1 l2
```

Is there a type for that (guarantee)?

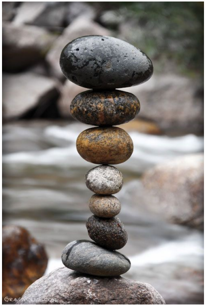
- `l1` and `l2` the same length.
- `l2` only contains strictly positive integers.
- This is a terminating computation.
- `List.map2` enjoys a linear complexity.
- `map2` is productive [1].
- This is a pure computation.
- ...

[1] Even if `l1` and `l2` are infinite, any finite prefix of the result can be observed.

Richer types, complex trade-offs

```
(* f : 'a list -> 'b list -> ('a * 'b) list *)
let f l1 l2 = List.map2 mkPair l1 l2
```

Type systems designers are like rock balancing artists



Principality
Efficient type checking
Usefulness
Decidability
Soundness
Expressivity

and, according to them, ML sits at a sweet spot in the design space.

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Expressivity vs Tractability

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As a programming tool, a type system must not only be expressive and sound but it must also fulfill some (maybe more informal) practical properties: typechecking must be efficient, types must be palatable, type inference should be predictable, types should be erasable, etc.

Motto

Make type systems as rich as possible while keeping an eye on their implementation.

Something to chew on

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More technically, we focus on type systems equipped with rules like:

$$\frac{\Gamma \vdash t : T_1 \qquad \Gamma \vdash T_1 \mathcal{R} T_2}{\Gamma \vdash t : T_2}$$

where $\mathcal{R}$ is typically some equivalence or partial order over types.

This part of the course

- Act 1: ML and type inference.
- Act 2: Subtyping.
- Act 3: Dependently-typed systems for programming.
- Act 4: Functional correctness.
- Act 5: Effects and resources (or module systems).

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