

MakeNoise<AtomDomain<T>, AbsoluteDistance<QI>, MO> for FloatExpFamily<P>

Michael Shoemate

This proof resides in “**contrib**” because it has not completed the vetting process.

Proves soundness of the implementation of **MakeNoise** over scalars for **FloatExpFamily** in **mod.rs** at **commit f5bb719** (outdated¹).

The intuition of this implementation is that a vector-valued mechanism can be used to privatize a scalar-valued input, by transforming the input into a singleton vector, applying the vector mechanism, and then unpacking the resulting singleton vector.

This matches the code and proof for the integer case, **MakeNoise<AtomDomain<T>, AbsoluteDistance<QI>, MO> for IntExpFamily<P>**, except for elementary data type.

1 Hoare Triple

Precondition

Compiler-Verified

- Generic MO implements trait **Measure**
- Generic T implements trait **Float** and **SaturatingCast<IBig>** The saturating cast is for infallible postprocessing of big ints back to type T.
- Const-generic P is of type **usize**
- Generic QI implements trait **Integer**
- Type IBig implements trait **From<T>**. This infallible exact cast is for converting integers to big ints in the preprocessing transformation.
- Type RBig implements trait **TryFrom<QI>**. This is for fallible casting from input sensitivity of type QI to a rational in the privacy map.
- Type ZExpFamily<P> implements trait **NoisePrivacyMap<LpDistance<P, RBig>, MO>**. This bound requires that it must be possible to construct a privacy map for this combination of noise distribution, distance type and privacy measure.

User-Verified

None

¹See new changes with `git diff f5bb719..92ee78b9 rust/src/measurements/noise/nature/float/mod.rs`

Pseudocode

```
1 class FloatExpFamily:
2     def make_noise(self, input_space) -> Measurement[AtomDomain[T], T, AbsoluteDistance[QI],
      MO]:
3         t_vec = make_vec(input_space) #
4         m_noise = self.make_noise(t_vec.output_space()) #
5
6         return t_vec >> m_noise >> then_index_or_default(0) #
```

Postcondition

Theorem 1.1.

Theorem 1.2. For every setting of the input parameters (`self`, `input_space`, `MO`, `T`, `P`, `QI`) to `make_noise` such that the given preconditions hold, `make_noise` raises an exception (at compile time or run time) or returns a valid measurement. A valid measurement has the following property:

1. (Privacy guarantee). For every pair of elements x, x' in `input_domain` and for every pair (d_in, d_out) , where `d_in` has the associated type for `input_metric` and `d_out` has the associated type for `output_measure`, if x, x' are `d_in`-close under `input_metric`, `privacy_map(d_in)` does not raise an exception, and `privacy_map(d_in) ≤ d_out`, then `function(x), function(x')` are `d_out`-close under `output_measure`.

Proof. Neither constructor `make_vec` nor `MakeNoise.make_noise` have manual preconditions, and the postconditions guarantee a valid transformation and valid measurement, respectively. `then_index_or_default` also does not have preconditions, and its postcondition guarantees that it returns a valid postprocessor.

The chain of a valid transformation, valid measurement and valid postprocessor is a valid measurement. \square