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Lerche: Generating data file processors in Julia from EBNF grammars

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Summary

In a scientific context, structured text is commonly encountered in data files and domain-specific languages (DSLs) for handling data. Extended Backhaus-Naur Format (EBNF) (ISO Central Secretary, 1996) is a well-established standard for describing the syntax of such structured text. A useful subset of such grammars is known as `LALR(1)`, meaning that the grammars describe text that can be unambiguously parsed based only on the tokens already seen and the next token of input (DeRemer, 1969). LALR(1) stands out for being able to parse most programming languages, while guaranteeing O(n) run-time complexity and very light memory use. Julia package `Lerche` automatically generates a parser that processes any data file or domain-specific language that can be described using a LALR(1) EBNF. The parse tree can be immediately transformed into application-specific data structures using user-supplied rules. This parser generator fills a gap in standards-based scientific work for the Julia ecosystem.

Statement of Need

Standards for scientific data formats are essential for correct interpretation of data produced and consumed by parties that are not in direct contact. Standardisation is also becoming increasingly important as requirements for accessible and reusable data increase among funding bodies and publishers. Use of formal description languages, such as EBNF, remove ambiguity that may arise when using natural language descriptions for these standards. Furthermore, a parser that is machine-generated from an EBNF description is guaranteed to generate a correct parse tree from conformant data, unlike hand-written parsers. In addition, development of a formal scientific standard written using EBNF is aided by the availability of EBNF parsers that identify ambiguities and errors.

Scientific data readers typically form a small component of larger projects, which will dictate the programming environment and policies. This environment restricts the choice of EBNF parser generators; an EBNF parser generator that executes in the usual project environment is preferable to one that introduces new build-time dependencies and environments. `Lerche` was translated into Julia from the Python Lark project (Shinan, 2021) in order to remove the need for any extra language dependencies or build steps when developing standards-conformant data format readers for Julia projects. The generated parsers run within the Julia language environment, and are straightforward to integrate into larger Julia projects.

Other native parser tools available for Julia projects include `ParserCombinator` (Cooke, 2021), `Pegparser` (Schneider, 2020), and the built-in Julia macro system. None of these

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take EBNF as input. Reliance on EBNF parser generators external to the Julia environment, for example by calling Lark or pre-generating parsers, complicate distribution and create a barrier to user contribution to packages.

dREL (Spadaccini et al., 2012) is a relational data processing language for specifying crystallographic algorithms. The dREL LALR(1) EBNF (Hester, 2021a) was developed using `Lerche` to verify its correctness and conformance to LALR(1) requirements. Package `DrelTools` (Hester, 2021b) is built around the parser automatically generated by `Lerche` from this EBNF. `Lerche` is also used by `CrystalInfoFramework` (Hester, 2021c) to generate the parser for data files written in the Crystallographic Information Framework (CIF) format (Bernstein et al., 2016).

Features

`Lerche` optionally augments the range of applicable EBNF grammars by using contextual lexing. In this mode, only those tokens that are possible in the current parsing state are matched by the lexer, which can be useful for grammars in which certain character sequences match more than one type of token; for example, a keyword may also be a possible value for a plain sequence of characters in certain contexts, in which case a non-contextual lexer might wrongly fail to recognise the keyword.

The Lark grammars recognised by `Lerche` extend the EBNF standard in several ways. To aid in composability, they support templating, and importing rules and terminals from other grammars. To aid in refactoring, they support expressing rule semantics, which are translatable to common tree operations. For example, rules starting with _ are considered to be auxiliary, and don't produce their own node. Terminals starting with _ aren't included in the tree, which is often desired for punctation such as commas and parentheses. In order to resolve possible ambiguities or conflicts, there is support for specifying priority in terminals and rules.

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