Partial with Free Variables — *Smooth CoffeeScript*

This literate program is *interactive* in its HTML form. Edit a CoffeeScript segment to try it.

Partial function application with free variables

Partial function application is presented in Smooth CoffeeScript partial application. It is a way to create a function from another function where the first arguments are filled in. With the new function we can then ignore those arguments so subsequent calls become easier to read and write.

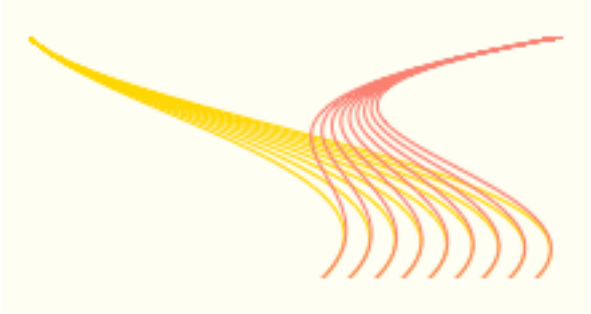
It is not always the case that arguments are so nicely ordered that it is the first ones that need to be held constant. To handle the general case with arbitrary arguments, a special symbol[1] can designate free variables i.e. those arguments that are not fixed.

In the code below[2] the `movement` function is inspired by the canvas function `bezierCurveTo`. It takes nine arguments, clearly outdoing `bezierCurveTo`'s measly six arguments. When calling such a function from many places, several of the arguments may well be the same.

```
draw = (ctx) -> # Try changing colors below
  ctx.beginPath(); ctx.strokeStyle = 'gold'
  drawMove ctx, (ix for ix in [0...90] by 10)
  ctx.beginPath(); ctx.strokeStyle = 'salmon'
  drawPath ctx, (ix for ix in [0...90] by 10)

movement = (ctx, ax, ay, cp1x, cp1y, cp2x, cp2y, x, y) ->
  ctx.moveTo ax, ay
  ctx.bezierCurveTo cp1x, cp1y, cp2x, cp2y, x, y

drawMove = (ctx, args) ->
  args.forEach (ix) -> movement ctx,
    0, 0, 30, 30, 150+ix, 50, 110+ix, 90
  ctx.stroke()
```



[1] In the examples underscore _ is used. You may want to choose another symbol to avoid clashes with commonly used libraries such as Underscore.

[2] To run this example standalone you can prepend this CoffeeKup CoffeeScript:

```
show = if exports? then console.log else alert
(require 'fs').writeFileSync "./bezier.html",
  webpage = (require 'coffeekup').render ->
    doctype 5
    html -> meta charset: 'utf-8',
      head -> title 'Bezier path'
      body ->
        canvas id: 'drawCanvas', width: 300, height: 200
        coffeescript ->
          window.onload = ->
            canvas = document.getElementById 'drawCanvas'
            ctx = canvas.getContext '2d'
            alert 'No canvas in this browser.' unless ctx?
            draw ctx if draw?
```

A wrapper function `swirl` that takes only those arguments that might change can cut down on the repetition. The `partialFree` function returns a new function when given a function, its fixed arguments and the placeholder symbol for the variable arguments.

```
_ = undefined
partialFree = (func, a...) -> (b...) ->
  b.reverse()
  func (for arg in a then arg ?= b.pop())...

swirl = partialFree movement, _, _, 0, 30, 30, _, 50, _, 90

drawPath = (ctx, args) ->
  args.forEach (ix) -> swirl ctx, 200, 150+ix, 110+ix
  ctx.stroke()
```

Prior Art

Where did the definition of `partialFree` come from? It started with a search for existing implementations. The search eventually turned up this JavaScript version from Angus Croll's blog.

```
window.___ = {}; //argument placeholder

Function.prototype.partial = function() {
    if (arguments.length<1) {
        //nothing to pre-assign - return the function as is
        return this;
    }
    var __method = this;
    var args = arguments;
    return function() {
        //build up new arg list, for placeholders use current arg,
        //otherwise copy original args
        var argIndex = 0, myArgs = [];
        for (var i = 0; i < args.length; i++) {
            myArgs[i] = window.___==args[i] ?
                arguments[argIndex++] : args[i];
        }
        return __method.apply(this, myArgs);
    }
}
```

And this CoffeeScript version from Mirotin.

```
_ = {}
partial15lines = () ->
  [func, args...] = arguments
  wrapper = () ->
    i = 0
    j = 0
    res_args = []
    while i < args.length
      if args[i] == _
        res_args.push arguments[j]
        j++
      else
        res_args.push args[i]
      i++
    return func.apply null, res_args
```

Stepwise CoffeeScript Improvements

Those implementations are fine and usable as they are. But here comes one of the most fun activities in CoffeeScript: *code reduction*. It is also useful because less code makes maintenance easier — up to a point — too clever tricks and the code can become harder to understand. In the following line of code reductions, which one would you choose as the best balance between brevity and readability?

In `partial15lines` there are some redundant words that can be removed. The use of arguments can also be replaced with a splat ...

```
_ = {}
partial12lines = (func, args...) ->
  (moreargs...) ->
    i = j = 0
    res_args = []
    while i < args.length
      if args[i] == _
        res_args.push moreargs[j++]
      else
        res_args.push args[i]
      i++
    func.apply null, res_args
```

In CoffeeScript `while` is an expression that returns the value of its inner block, so there is no need for pushing values to a results array.

```
_ = {}
partial10lines = (func, args...) ->
  (moreargs...) ->
    i = j = 0
    func.apply null,
      while i++ < args.length
        if args[i-1] == _
          moreargs[j++]
        else
          args[i-1]
```

A `for` loop instead of the `while` gets rid of the `length` check. A splat can also be used in a call which eliminates the `apply`. The old school == can be replaced with `is`.

```
_ = {}
partial8lines = (func, a...) -> (b...) ->
  i = 0
  func (for arg in a
    if arg is _
      b[i++]
    else
      arg)...
```

The low level counter `i` is only used to get the next argument from `b`. The same effect can be achieved by treating `b` as a LIFO (Last In First Out) buffer. To do that `b` has to be reversed.

```
_ = {}
partial5lines = (func, a...) -> (b...) ->
  b.reverse()
  func (for arg in a
    if arg is _ then b.pop() else arg)...
```

Instead of using an empty object as the placeholder, using `undefined` allows the `if` test to be replaced with an existential assignment ?=.

```
_ = undefined
partial4lines = (func, a...) -> (b...) ->
  b.reverse()
  func (for arg in a then arg ?= b.pop())...
```

Test

A couple of test cases and an example of `partial`. In the interactive HTML you can try substituting the number in `partial4lines` to test the other versions.

```
test = ->
  f = (x, y, z) -> x + 2*y + 5*z
  g = partialFree f, _, 1, _
  show "g 3, 5 => #{g 3, 5} Expected: 30"

  # Modified from an alexkg example
  fold = (f, z, xs) ->
    z = f(z, x) for x in xs
    z
  max = partialFree fold, Math.max, -Infinity, _
  show "max [-10..10] => #{max [-10..10]} Expected: 10"

  # Without free vars
  partial = (f, a...) -> (b...) -> f a..., b...
  min = partial fold, Math.min, Infinity
  show "min [-10..10] => #{min [-10..10]} Expected: -10"
partialFree = partial4lines
test()
```

Output

```
g 3, 5 => 30 Expected: 30
max [-10..10] => 10 Expected: 10
min [-10..10] => -10 Expected: -10
```

JavaScript

```
(function() {
  var draw, drawMove, drawPath, movement, partial10lines, partial12lines, partial15lines, partial4lines, partial5lines, partial8lines
  var __slice = Array.prototype.slice;

  draw = function(ctx) {
    var ix;
    ctx.beginPath();
    ctx.strokeStyle = 'gold';
    drawMove(ctx, (function() {
      var _results;
      _results = [];
      for (ix = 0; ix < 90; ix += 10) {
        _results.push(ix);
      }
      return _results;
    })());
    ctx.beginPath();
    ctx.strokeStyle = 'salmon';
    return drawPath(ctx, (function() {
      var _results;
      _results = [];
      for (ix = 0; ix < 90; ix += 10) {
        _results.push(ix);
      }
      return _results;
    })());
  };
```

```
28
29      movement = function(ctx, ax, ay, cp1x, cp1y, cp2x, cp2y, x, y) {
30        ctx.moveTo(ax, ay);
31        return ctx.bezierCurveTo(cp1x, cp1y, cp2x, cp2y, x, y);
32      };
33
34      drawMove = function(ctx, args) {
35        args.forEach(function(ix) {
36          return movement(ctx, 0, 0, 30, 30, 150 + ix, 50, 110 + ix, 90);
37        });
38        return ctx.stroke();
39      };
40
41      _ = void 0;
42
43      partialFree = function() {
44        var a, func;
45        func = arguments[0], a = 2 <= arguments.length ? __slice.call(arguments, 1) : [];
46        return function() {
47          var arg, b;
48          b = 1 <= arguments.length ? __slice.call(arguments, 0) : [];
49          b.reverse();
50          return func.apply(null, (function() {
51            var _i, _len, _results;
52            _results = [];
53            for (_i = 0, _len = a.length; _i < _len; _i++) {
54              arg = a[_i];
55              _results.push(arg != null ? arg : arg = b.pop());
56            }
57            return _results;
58          })());
59        };
60      };
61
62      swirl = partialFree(movement, _, _, 0, 30, 30, _, 50, _, 90);
63
64      drawPath = function(ctx, args) {
65        args.forEach(function(ix) {
66          return swirl(ctx, 200, 150 + ix, 110 + ix);
67        });
68        return ctx.stroke();
69      };
70
71      _ = {};
72
73      partial15lines = function() {
74        var args, func, wrapper;
75        func = arguments[0], args = 2 <= arguments.length ? __slice.call(arguments, 1) : [];
76        return wrapper = function() {
77          var i, j, res_args;
78          i = 0;
79          j = 0;
80          res_args = [];
81          while (i < args.length) {
82            if (args[i] === _) {
83              res_args.push(arguments[j]);
84              j++;
85            } else {
86              res_args.push(args[i]);
87            }
88            i++;
89          }
90          return func.apply(null, res_args);
91        };
92      };
93
94      _ = {};
95
96      partial12lines = function() {
97        var args, func;
98        func = arguments[0], args = 2 <= arguments.length ? __slice.call(arguments, 1) : [];
99        return function() {
```

```
      var i, j, moreargs, res_args;
      moreargs = 1 <= arguments.length ? __slice.call(arguments, 0) : [];
      i = j = 0;
      res_args = [];
      while (i < args.length) {
        if (args[i] === _) {
          res_args.push(moreargs[j++]);
        } else {
          res_args.push(args[i]);
        }
        i++;
      }
      return func.apply(null, res_args);
    };
  };

  _ = {};

  partial10lines = function() {
    var args, func;
    func = arguments[0], args = 2 <= arguments.length ? __slice.call(arguments, 1) : [];
    return function() {
      var i, j, moreargs;
      moreargs = 1 <= arguments.length ? __slice.call(arguments, 0) : [];
      i = j = 0;
      return func.apply(null, (function() {
        var _results;
        _results = [];
        while (i++ < args.length) {
          if (args[i - 1] === _) {
            _results.push(moreargs[j++]);
          } else {
            _results.push(args[i - 1]);
          }
        }
        return _results;
      })());
    };
  };

  _ = {};

  partial8lines = function() {
    var a, func;
    func = arguments[0], a = 2 <= arguments.length ? __slice.call(arguments, 1) : [];
    return function() {
      var arg, b, i;
      b = 1 <= arguments.length ? __slice.call(arguments, 0) : [];
      i = 0;
      return func.apply(null, (function() {
        var _i, _len, _results;
        _results = [];
        for (_i = 0, _len = a.length; _i < _len; _i++) {
          arg = a[_i];
          if (arg === _) {
            _results.push(b[i++]);
          } else {
            _results.push(arg);
          }
        }
        return _results;
      })());
    };
  };

  _ = {};

  partial5lines = function() {
    var a, func;
    func = arguments[0], a = 2 <= arguments.length ? __slice.call(arguments, 1) : [];
    return function() {
      var arg, b;
```

```
      b = 1 <= arguments.length ? __slice.call(arguments, 0) : [];
      b.reverse();
      return func.apply(null, (function() {
        var _i, _len, _results;
        _results = [];
        for (_i = 0, _len = a.length; _i < _len; _i++) {
          arg = a[_i];
          if (arg === _) {
            _results.push(b.pop());
          } else {
            _results.push(arg);
          }
        }
        return _results;
      })());
    };
  };

  _ = void 0;

  partial4lines = function() {
    var a, func;
    func = arguments[0], a = 2 <= arguments.length ? __slice.call(arguments, 1) : [];
    return function() {
      var arg, b;
      b = 1 <= arguments.length ? __slice.call(arguments, 0) : [];
      b.reverse();
      return func.apply(null, (function() {
        var _i, _len, _results;
        _results = [];
        for (_i = 0, _len = a.length; _i < _len; _i++) {
          arg = a[_i];
          _results.push(arg != null ? arg : arg = b.pop());
        }
        return _results;
      })());
    };
  };

  test = function() {
    var f, fold, g, max, min, partial;
    f = function(x, y, z) {
      return x + 2 * y + 5 * z;
    };
    g = partialFree(f, _, 1, _);
    show("g 3, 5 => " + (g(3, 5)) + " Expected: 30");
    fold = function(f, z, xs) {
      var x, _i, _len;
      for (_i = 0, _len = xs.length; _i < _len; _i++) {
        x = xs[_i];
        z = f(z, x);
      }
      return z;
    };
    max = partialFree(fold, Math.max, -Infinity, _);
    show("max [-10..10] => " + (max([-10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10])) + " Expected: 10")
    partial = function() {
      var a, f;
      f = arguments[0], a = 2 <= arguments.length ? __slice.call(arguments, 1) : [];
      return function() {
        var b;
        b = 1 <= arguments.length ? __slice.call(arguments, 0) : [];
        return f.apply(null, __slice.call(a).concat(__slice.call(b)));
      };
    };
    min = partial(fold, Math.min, Infinity);
    return show("min [-10..10] => " + (min([-10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10])) + " Expecte
  };

  partialFree = partial4lines;

  test();
```

```
244
245 }).call(this);
```

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