HTML Canvas 2D Context

W3C Recommendation 19 November 2015

This Version:
http://www.w3.org/TR/2015/REC-2dcontext-20151119/
Latest Published Version:
http://www.w3.org/TR/2dcontext/
Previous Version:
http://www.w3.org/TR/2015/PR-2dcontext-20150924/

Editors:
W3C:
Rik Cabanier, Adobe Systems, Inc.
Jatinder Mann, Microsoft Corporation
Jay Munro, Microsoft Corporation
Tom Wiltzius, Google, Inc.
WHATWG:
Ian Hickson, Google, Inc.

Please check the **errata** for any errors or issues reported since publication.
See also **translations**.

Abstract

This specification defines the 2D Context for the HTML `canvas` element. The 2D Context provides objects, methods, and properties to draw and manipulate graphics on a `canvas` drawing surface.

Status of This Document

This section describes the status of this document at the time of its publication. Other documents may supersede this document. A list of current W3C publications and the latest revision of this technical report can be found in the W3C technical reports index at http://www.w3.org/TR/.

This is the specification for the 2D Context for the HTML canvas element, published by the HTML Working Group.

If you wish to make comments regarding this document in a manner that is tracked by the W3C, please submit them via using our public issues list. If you cannot do this then you can also e-mail feedback to public-canvas-api@w3.org (subscribe, archives), and arrangements will be made to transpose the comments to our public bug database. All feedback is welcome.

By publishing this Recommendation, W3C expects the functionality specified in this Recommendation will not be affected by changes to Web IDL, CSS Object Model, CSS Images Values, or CSS Fonts as those specifications proceed to Recommendation.

Work on extending this specification typically proceeds through extension specifications which should be consulted to see what new features are being reviewed.

The bulk of the text of this specification is also available in the WHATWG HTML Living Standard, under a license that permits reuse of the specification text.

Work on this specification is also done at the WHATWG. The W3C HTML working group actively pursues convergence of the HTML specification with the WHATWG living standard, within the bounds of the W3C HTML working group charter. There are various ways to follow this work at the WHATWG:

- Commit-Watchers mailing list (complete source diffs): http://lists.whatwg.org/listinfo.cgi/commit-watchers-whatwg.org
- Github commits: https://github.com/whatwg/html/commits

This document has been reviewed by W3C Members, by software developers, and by other W3C groups and interested parties, and is endorsed by the Director as a W3C Recommendation. It is a stable document and may be used as reference material or cited from another document. W3C's role in making the Recommendation is to draw attention to the specification and to promote its widespread deployment. This enhances the functionality and interoperability of the Web.

The old issue list is still available. No changes were done since the previous publication.

During the Candidate Recommendation phase, the group made available an implementation report as well as its companion report for `drawFocusIfNeeded` and `addHitRegion`.

This specification is an extension to the HTML5 language. All normative content in the HTML5 specification, unless specifically overridden by this specification, is intended to be the basis for this specification.

This document was produced by a group operating under the 5 February 2004 W3C Patent Policy. W3C maintains a public list of any patent disclosures made in connection with the deliverables of the group; that page also includes instructions for disclosing a patent. An individual who has actual knowledge of a patent which the individual believes contains Essential Claim(s) must disclose the information in accordance with section 6 of the W3C Patent Policy.

This document is governed by the 14 October 2005 W3C Process Document.

Table of Contents

1 Conformance requirements

This specification is an HTML specification. All the conformance requirements, conformance classes, definitions, dependencies, terminology, and typographical conventions described in the core HTML5 specification apply to this specification. [HTML]

Interfaces are defined in terms of Web IDL. [WEBIDL]

This specification defines the `2d` context type, whose API is implemented using the `CanvasRenderingContext2D` interface.

When the `getContext()` method of a `canvas` element is to return a new object for the *contextId* `2d`, the user agent must return a new `CanvasRenderingContext2D` object. Any additional arguments are ignored.

The 2D context represents a flat Cartesian surface whose origin (0,0) is at the top left corner, with the coordinate space having *x* values increasing when going right, and *y* values increasing when going down.

IDL

```
typedef (HTMLImageElement or
         HTMLVideoElement or
         HTMLCanvasElement) CanvasImageSource;

interface CanvasRenderingContext2D {

  // back-reference to the canvas
  readonly attribute HTMLCanvasElement canvas;

  // state
  void save(); // push state on state stack
  void restore(); // pop state stack and restore state

  // transformations (default: transform is the identity matrix)
  void scale(unrestricted double x, unrestricted double y);
  void rotate(unrestricted double angle);
  void translate(unrestricted double x, unrestricted double y);
  void transform(unrestricted double a, unrestricted double b, unrestricted double
c, unrestricted double d, unrestricted double e, unrestricted double f);
  void setTransform(unrestricted double a, unrestricted double b, unrestricted
double c, unrestricted double d, unrestricted double e, unrestricted double f);

  // compositing
           attribute unrestricted double globalAlpha; // (default: 1.0)
           attribute DOMString globalCompositeOperation; // (default: "source-over")

  // colors and styles (see also the CanvasDrawingStyles interface)
           attribute (DOMString or CanvasGradient or CanvasPattern) strokeStyle; //
(default: "black")
           attribute (DOMString or CanvasGradient or CanvasPattern) fillStyle; //
(default: "black")
  CanvasGradient createLinearGradient(double x0, double y0, double x1, double y1);
  CanvasGradient createRadialGradient(double x0, double y0, double r0, double x1,
double y1, double r1);
  CanvasPattern createPattern(CanvasImageSource image, [TreatNullAs=EmptyString]
DOMString repetition);

  // shadows
           attribute unrestricted double shadowOffsetX; // (default: 0)
           attribute unrestricted double shadowOffsetY; // (default: 0)
           attribute unrestricted double shadowBlur; // (default: 0)
           attribute DOMString shadowColor; // (default: "transparent black")

  // rects
  void clearRect(unrestricted double x, unrestricted double y, unrestricted double
w, unrestricted double h);
  void fillRect(unrestricted double x, unrestricted double y, unrestricted double
w, unrestricted double h);
  void strokeRect(unrestricted double x, unrestricted double y, unrestricted double
w, unrestricted double h);

  // path API (see also CanvasPathMethods)
  void beginPath();
  void fill();
  void stroke();
  void drawFocusIfNeeded(Element element);
  void clip();
  boolean isPointInPath(unrestricted double x, unrestricted double y);

  // text (see also the CanvasDrawingStyles interface)
  void fillText(DOMString text, unrestricted double x, unrestricted double y,
optional unrestricted double maxWidth);
  void strokeText(DOMString text, unrestricted double x, unrestricted double y,
optional unrestricted double maxWidth);
  TextMetrics measureText(DOMString text);

  // drawing images
  void drawImage(CanvasImageSource image, unrestricted double dx, unrestricted
double dy);
  void drawImage(CanvasImageSource image, unrestricted double dx, unrestricted
double dy, unrestricted double dw, unrestricted double dh);
  void drawImage(CanvasImageSource image, unrestricted double sx, unrestricted
double sy, unrestricted double sw, unrestricted double sh, unrestricted double dx,
unrestricted double dy, unrestricted double dw, unrestricted double dh);

  // hit regions
  void addHitRegion(HitRegionOptions options);
  void removeHitRegion(DOMString id);
  void clearHitRegions();

  // pixel manipulation
  ImageData createImageData(unrestricted double sw, unrestricted double sh);
  ImageData createImageData(ImageData imagedata);
  ImageData getImageData(double sx, double sy, double sw, double sh);
  void putImageData(ImageData imagedata, double dx, double dy);
  void putImageData(ImageData imagedata, double dx, double dy, double dirtyX,
double dirtyY, double dirtyWidth, double dirtyHeight);
};
CanvasRenderingContext2D implements CanvasDrawingStyles;
CanvasRenderingContext2D implements CanvasPathMethods;

[NoInterfaceObject]
interface CanvasDrawingStyles {
  // line caps/joins
           attribute unrestricted double lineWidth; // (default: 1)
           attribute DOMString lineCap; // "butt", "round", "square" (default:
"butt")
           attribute DOMString lineJoin; // "round", "bevel", "miter" (default:
"miter")
           attribute unrestricted double miterLimit; // (default: 10)

  // dashed lines
  void setLineDash(sequence<unrestricted double> segments); // (default: empty)
  sequence<unrestricted double> getLineDash();
           attribute unrestricted double lineDashOffset;


  // text
           attribute DOMString font; // (default: "10px sans-serif")
           attribute DOMString textAlign; // "start", "end", "left", "right",
"center" (default: "start")
           attribute DOMString textBaseline; // "top", "hanging", "middle",
"alphabetic", "ideographic", "bottom" (default: "alphabetic")
};

[NoInterfaceObject]
interface CanvasPathMethods {
  // shared path API methods
  void closePath();
  void moveTo(unrestricted double x, unrestricted double y);
  void lineTo(unrestricted double x, unrestricted double y);
  void quadraticCurveTo(unrestricted double cpx, unrestricted double cpy,
unrestricted double x, unrestricted double y);
  void bezierCurveTo(unrestricted double cp1x, unrestricted double cp1y,
unrestricted double cp2x, unrestricted double cp2y, unrestricted double x,
unrestricted double y);
  void arcTo(unrestricted double x1, unrestricted double y1, unrestricted double
x2, unrestricted double y2, unrestricted double radius);
  void rect(unrestricted double x, unrestricted double y, unrestricted double w,
unrestricted double h);
```

```
  void arc(unrestricted double x, unrestricted double y, unrestricted double
radius, unrestricted double startAngle, unrestricted double endAngle, optional
boolean counterclockwise = false);

  };

interface CanvasGradient {
  // opaque object
  void addColorStop(double offset, DOMString color);
};

interface CanvasPattern {
  // opaque object
};

interface TextMetrics {
  readonly attribute double width;
};

dictionary HitRegionOptions {
  // dictionary to allow expansion on Hit Regions in Canvas Context 2D Level 2
  DOMString id = "";
  // for control-backed regions:
  Element? control = null;
};

interface ImageData {
  readonly attribute unsigned long width;
  readonly attribute unsigned long height;
  readonly attribute Uint8ClampedArray data;
};
```

Note:

***context* . canvas**

Returns the `canvas` element.

The **`canvas`** attribute must return the `canvas` element that the context paints on.

Except where otherwise specified, for the 2D context interface, **any method call with a numeric argument whose value is infinite or a NaN value must be ignored**.

Whenever the CSS value `currentColor` is used as a color in this API, the "computed value of the 'color' property" for the purposes of determining the computed value of the `currentColor` keyword is the computed value of the 'color' property on the element in question at the time that the color is specified (e.g. when the appropriate attribute is set, or when the method is called; not when the color is rendered or otherwise used). If the computed value of the 'color' property is undefined for a particular case (e.g. because the element is not in a `Document`), then the "computed value of the 'color' property" for the purposes of determining the computed value of the `currentColor` keyword is fully opaque black. [CSSCOLOR]

In the case of `addColorStop()` on `CanvasGradient`, the "computed value of the 'color' property" for the purposes of determining the computed value of the `currentColor` keyword is always fully opaque black (there is no associated element). [CSSCOLOR]

> **Note:** This is because `CanvasGradient` objects are `canvas`-neutral — a `CanvasGradient` object created by one `canvas` can be used by another, and there is therefore no way to know which is the "element in question" at the time that the color is specified.

> **Note:** Similar concerns exist with font-related properties; the rules for those are described in detail in the relevant section below.

2 The canvas state

Each context maintains a stack of drawing states. **Drawing states** consist of:

- The current transformation matrix.
- The current clipping region.
- The current values of the following attributes: `strokeStyle`, `fillStyle`, `globalAlpha`, `lineWidth`, `lineCap`, `lineJoin`, `miterLimit`, `shadowOffsetX`, `shadowOffsetY`, `shadowBlur`, `shadowColor`, `globalCompositeOperation`, `font`, `textAlign`, `textBaseline`.

> **Note:** The current path and the current bitmap are not part of the drawing state. The current path is persistent, and can only be reset using the `beginPath()` method. The current bitmap is a property of the canvas, not the context.

Note:

context **.** `save`**()**

Pushes the current state onto the stack.

context **.** `restore`**()**

Pops the top state on the stack, restoring the context to that state.

The **`save()`** method must push a copy of the current drawing state onto the drawing state stack.

The **`restore()`** method must pop the top entry in the drawing state stack, and reset the drawing state it describes. If there is no saved state, the method must do nothing.

3 Line styles

Note:

context **. `lineWidth` [= *value*]**

Returns the current line width.

Can be set, to change the line width. Values that are not finite values greater than zero are ignored.

context **. `lineCap` [= *value*]**

Returns the current line cap style.

Can be set, to change the line cap style.

The possible line cap styles are "`butt`", "`round`", and "`square`". Other values are ignored.

context **. `lineJoin` [= *value*]**

Returns the current line join style.

Can be set, to change the line join style.

The possible line join styles are "`bevel`", "`round`", and "`miter`". Other values are ignored.

context **. `miterLimit` [= *value*]**

Returns the current miter limit ratio.

Can be set, to change the miter limit ratio. Values that are not finite values greater than zero are ignored.

context **. `setLineDash`(*segments*)**

Sets the current line dash pattern (as used when stroking). The argument is an array of distances for which to alternately have the line on and the line off.

segments **=** ***context*** **. `getLineDash`()**

Returns a copy of the current line dash pattern. The array returned will always have an even number of entries (i.e. the pattern is normalized).

context **. `lineDashOffset` [= *value*]**

Returns the phase offset (in the same units as the line dash pattern).

Can be set, to change the phase offset. Values that are not finite values are ignored.

Objects that implement the `CanvasDrawingStyles` interface have attributes and methods (defined in this section) that control how lines are treated by the object.

The **`lineWidth`** attribute gives the width of lines, in coordinate space units. On getting, it must return the current value. On setting, zero, negative, infinite, and NaN values must be ignored, leaving the value unchanged; other values must change the current value to the new value.

When the object implementing the `CanvasDrawingStyles` interface is created, the `lineWidth` attribute must initially have the value `1.0`.

The **`lineCap`** attribute defines the type of endings that UAs will place on the end of lines. The three valid values are "`butt`", "`round`", and "`square`".

On getting, it must return the current value. On setting, if the new value is one of the literal strings "`butt`", "`round`", and "`square`", then the current value must be changed to the new value; other values must be ignored, leaving the value unchanged.

When the object implementing the `CanvasDrawingStyles` interface is created, the `lineCap` attribute must initially have the value "`butt`".

The **`lineJoin`** attribute defines the type of corners that UAs will place where two lines meet. The three valid values are "`bevel`", "`round`", and "`miter`".

On getting, it must return the current value. On setting, if the new value is one of the literal strings "`bevel`", "`round`", and "`miter`", then the current value must be changed to the new value; other values must be ignored, leaving the value unchanged.

When the object implementing the `CanvasDrawingStyles` interface is created, the `lineJoin` attribute must initially have the value "`miter`".

When the `lineJoin` attribute has the value "`miter`", strokes use the miter limit ratio to decide how to render joins. The miter limit ratio can be explicitly set using the **`miterLimit`** attribute. On getting, it must return the current value. On setting, zero, negative, infinite, and NaN values must be ignored, leaving the value unchanged; other values must change the current value to the new value.

When the object implementing the `CanvasDrawingStyles` interface is created, the `miterLimit` attribute must initially have the value `10.0`.

Each `CanvasDrawingStyles` object has a **dash list**, which is either empty or consists of an even number of positive non-zero numbers. Initially, the dash list must be empty.

When the **`setLineDash()`** method is invoked, it must run the following steps:

1. Let *a* be a copy of the array provided as the argument.
2. If any value in the array is not finite (e.g. an Infinity or a NaN value), or if any value is negative (less than zero), then abort these steps (without throwing an exception; user agents could show a message on a developer console, though, as that would be helpful for debugging).
3. If the number of elements in *a* is odd, then let *a* be the concatenation of two copies of *a*.
4. Let the object's dash list be *a*.

When the **`getLineDash()`** method is invoked, it must return a newly created array whose values are the values of the object's dash list, in the same order.

It is sometimes useful to change the "phase" of the dash pattern, e.g. to achieve a "marching ants" effect. The phase can be set using the **`lineDashOffset`** attribute. On getting, it must return the current value. On setting, infinite and NaN values must be ignored, leaving the value unchanged; other values must change the current value to the new value.

When the object implementing the `CanvasDrawingStyles` interface is created, the `lineDashOffset` attribute must initially have the value `0.0`.

When a user agent is to **trace a path**, given an object *style* that implements the `CanvasDrawingStyles` interface, it must run the following algorithm. This algorithm returns a new path.

1. Let *path* be a copy of the path being traced.
2. Prune all zero-length line segments from *path*.
3. Remove from *path* any subpaths containing no lines (i.e. subpaths with just one point).
4. Replace each point in each subpath of *path* other than the first point and the last point of each subpath by a *join* that joins the line leading to that point to the line leading out of that point, such that the subpaths all consist of two points (a starting point with a line leading out of it, and an ending point with a line leading into it), one or more lines (connecting the points and the joins), and zero or more joins (each connecting one line to another), connected together such that each subpath is a series of one or more lines with a join between each one and a point on each end.
5. Add a straight closing line to each closed subpath in *path* connecting the last point and the first

point of that subpath; change the last point to a join (from the previously last line to the newly added closing line), and change the first point to a join (from the newly added closing line to the first line).

6. If the *styles* dash list is empty, jump to the step labeled *convert*.

7. Let *pattern width* be the concatenation of all the entries of the *styles* dash list, in coordinate space units.

8. For each subpath *subpath* in *path*, run the following substeps. These substeps mutate the subpaths in *path in vivo*.

    1. Let *subpath width* be the length of all the lines of *subpath*, in coordinate space units.

    2. Let *offset* be the value of the *styles* `lineDashOffset`, in coordinate space units.

    3. While *offset* is greater than *pattern width*, decrement it by *pattern width*.

        While *offset* is less than zero, increment it by *pattern width*.

    4. Define *L* to be a linear coordinate line defined along all lines in *subpath*, such that the start of the first line in the subpath is defined as coordinate 0, and the end of the last line in the subpath is defined as coordinate *subpath width*.

    5. Let *position* be zero minus *offset*.

    6. Let *index* be 0.

    7. Let *current state* be *off* (the other states being *on* and *zero-on*).

    8. *Dash on*: Let *segment length* be the value of the *styles* dash list's *index*th entry.

    9. Increment *position* by *segment length*.

    10. If *position* is greater than *subpath width*, then end these substeps for this subpath and start them again for the next subpath; if there are no more subpaths, then jump to the step labeled *convert* instead.

    11. If *segment length* is non-zero, let *current state* be *on*.

    12. Increment *index* by one.

    13. *Dash off*: Let *segment length* be the value of the *styles* dash list's *index*th entry.

    14. Let *start* be the offset *position* on *L*.

    15. Increment *position* by *segment length*.

    16. If *position* is less than zero, then jump to the step labeled *post-cut*.

    17. If *start* is less than zero, then let *start* be zero.

    18. If *position* is greater than *subpath width*, then let *end* be the offset *subpath width* on *L*. Otherwise, let *end* be the offset *position* on *L*.

    19. Run one of the following substeps, as appropriate:

        ↪ **If *segment length* is zero and *current state* is *off***

        Do nothing, just continue to the next step.

        ↪ **If *current state* is *off***

        Cut the line on which *end* finds itself short at *end* and place a point there, cutting its containing subpath in two; remove all line segments, joins, points, and subpaths that are between *start* and *end*; and finally place a single point at *start* with no lines connecting to it.

The point has a *directionality* for the purposes of drawing line caps (see below). The directionality is the direction that the original line had at that point (i.e. when *L* was defined above).

↪ **Otherwise**

Cut the line on which *start* finds itself into two at *start* and place a point there, cutting the subpath that it was in in two, and similarly cut the line on which *end* finds itself short at *end* and place a point there, cutting the subpath that *it* was in in two, and then remove all line segments, joins, points, and subpaths that are between *start* and *end*.

If *start* and *end* are the same point, then this results in just the line being cut in two and two points being inserted there, with nothing being removed, unless a join also happens to be at that point, in which case the join must be removed.

20. *Post-cut*: If *position* is greater than *subpath width*, then jump to the step labeled *convert*.

21. If *segment length* is greater than zero, let *positioned-at-on-dash* be false.

22. Increment *index* by one. If it is equal to the number of entries in the *styles* dash list, then let *index* be 0.

23. Jump to the step labeled *dash on*.

9. *Convert*: This is the step that converts the path to a new path that represents its stroke.

Create a new path that describes the edge of the areas that would be covered if a straight line of length equal to the *styles* `lineWidth` was swept along each path in *path* while being kept at an angle such that the line is orthogonal to the path being swept, replacing each point with the end cap necessary to satisfy the *styles* `lineCap` attribute as described previously and elaborated below, and replacing each join with the join necessary to satisfy the *styles* `lineJoin` type, as defined below.

Caps: Each point has a flat edge perpendicular to the direction of the line coming out of it. This is them augmented according to the value of the *styles* `lineCap`. The "`butt`" value means that no additional line cap is added. The "`round`" value means that a semi-circle with the diameter equal to the *styles* `lineWidth` width must additionally be placed onto the line coming out of each point. The "`square`" value means that a rectangle with the length of the *styles* `lineWidth` width and the width of half the *styles* `lineWidth` width, placed flat against the edge perpendicular to the direction of the line coming out of the point, must be added at each point.

Points with no lines coming out of them must have two caps placed back-to-back as if it was really two points connected to each other by an infinitesimally short straight line in the direction of the point's *directionality* (as defined above).

Joins: In addition to the point where a join occurs, two additional points are relevant to each join, one for each line: the two corners found half the line width away from the join point, one perpendicular to each line, each on the side furthest from the other line.

A filled triangle connecting these two opposite corners with a straight line, with the third point of the triangle being the join point, must be added at all joins. The `lineJoin` attribute controls whether anything else is rendered. The three aforementioned values have the following meanings:

The "`bevel`" value means that this is all that is rendered at joins.

The "`round`" value means that a filled arc connecting the two aforementioned corners of the join, abutting (and not overlapping) the aforementioned triangle, with the diameter equal to the line width and the origin at the point of the join, must be added at joins.

The "`miter`" value means that a second filled triangle must (if it can given the miter length) be added at the join, with one line being the line between the two aforementioned corners, abutting the first triangle, and the other two being continuations of the outside edges of the two joining lines, as long as required to intersect without going over the miter length.

The miter length is the distance from the point where the join occurs to the intersection of the line edges on the outside of the join. The miter limit ratio is the maximum allowed ratio of the miter length to half the line width. If the miter length would cause the miter limit ratio (as set by the *style* `miterLimit` attribute) to be exceeded, this second triangle must not be added.

Subpaths in the newly created path must wind clockwise, regardless of the direction of paths in *path*.

10. Return the newly created path.

4 Text styles

Note:

context **. `font` [= *value*]**

Returns the current font settings.

Can be set, to change the font. The syntax is the same as for the CSS 'font' property; values that cannot be parsed as CSS font values are ignored.

Relative keywords and lengths are computed relative to the font of the `canvas` element.

context **. `textAlign` [= *value*]**

Returns the current text alignment settings.

Can be set, to change the alignment. The possible values are "`start`", "`end`", "`left`", "`right`", and "`center`". Other values are ignored. The default is "`start`".

context **. `textBaseline` [= *value*]**

Returns the current baseline alignment settings.

Can be set, to change the baseline alignment. The possible values and their meanings are given below. Other values are ignored. The default is "`alphabetic`".

The **`font`** IDL attribute, on setting, must be parsed the same way as the 'font' property of CSS (but without supporting property-independent style sheet syntax like 'inherit'), and the resulting font must be assigned to the context, with the 'line-height' component forced to 'normal', with the 'font-size' component converted to CSS pixels, and with system fonts being computed to explicit values. If the new value is syntactically incorrect (including using property-independent style sheet syntax like 'inherit' or 'initial'), then it must be ignored, without assigning a new font value. [CSS]

Font names must be interpreted in the context of the font style source node's stylesheets when the font is to be used; any fonts embedded using `@font-face` that are visible to that element must therefore be available once they are loaded. (If a reference font is used before it is fully loaded, or if the font style source node does not have that font in scope at the time the font is to be used, then it must be treated as if it was an unknown font, falling back to another as described by the relevant CSS specifications.) [CSSFONTS]

Only vector fonts should be used by the user agent; if a user agent were to use bitmap fonts then transformations would likely make the font look very ugly.

On getting, the `font` attribute must return the serialized form of the current font of the context (with no 'line-height' component). [CSSOM]

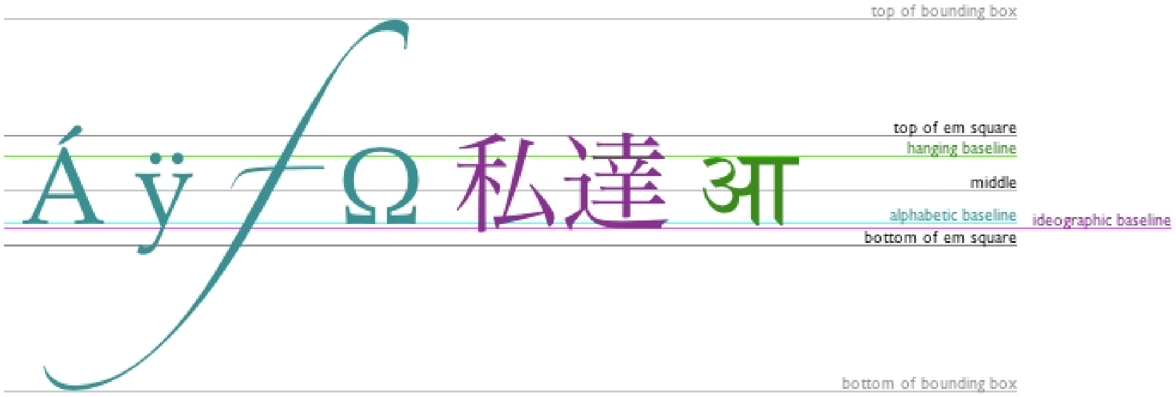
> **Code Example:**
>
> For example, after the following statement:
>
> ```
> context.font = 'italic 400 12px/2 Unknown Font, sans-serif';
> ```
>
> ...the expression `context.font` would evaluate to the string "`italic 12px "Unknown Font", sans-serif`". The "400" font-weight doesn't appear because that is the default value. The line-height doesn't appear because it is forced to "normal", the default value.

When the context is created, the font of the context must be set to 10px sans-serif. When the 'font-size' component is set to lengths using percentages, 'em' or 'ex' units, or the 'larger' or 'smaller' keywords, these must be interpreted relative to the computed value of the 'font-size' property of the font style source node at the time that the attribute is set, if that is an element. When the 'font-weight' component is set to the relative values 'bolder' and 'lighter', these must be interpreted relative to the computed value of the 'font-weight' property of the font style source node at the time that the attribute is set, if that is an element. If the computed values are undefined for a particular case (e.g. because the font style source node is not an element or is not in a `Document`), then the relative keywords must be interpreted relative to the normal-weight 10px sans-serif default.

The **`textAlign`** IDL attribute, on getting, must return the current value. On setting, if the value is one of "`start`", "`end`", "`left`", "`right`", or "`center`", then the value must be changed to the new value. Otherwise, the new value must be ignored. When the context is created, the `textAlign` attribute must initially have the value "`start`".

The **`textBaseline`** IDL attribute, on getting, must return the current value. On setting, if the value is one of "`top`", "`hanging`", "`middle`", "`alphabetic`", "`ideographic`", or "`bottom`", then the value must be changed to the new value. Otherwise, the new value must be ignored. When the object implementing the `CanvasDrawingStyles` interface is created, the `textBaseline` attribute must initially have the value "`alphabetic`".

The `textBaseline` attribute's allowed keywords correspond to alignment points in the font:



The keywords map to these alignment points as follows:

`top`
: The top of the em square

`hanging`
: The hanging baseline

`middle`
: The middle of the em square

`alphabetic`
: The alphabetic baseline

`ideographic`
: The ideographic baseline

`bottom`
: The bottom of the em square

The **text preparation algorithm** is as follows. It takes as input a string *text*, a `CanvasDrawingStyles` object *target*, and an optional length *maxWidth*. It returns an array of glyph shapes, each positioned on a common coordinate space, and a *physical alignment* whose value is one of *left*, *right*, and *center*. (Most callers of this algorithm ignore the *physical alignment*.)

1. If *maxWidth* was provided but is less than or equal to zero, return an empty array.

2. Replace all the space characters in *text* with U+0020 SPACE characters.

3. Let *font* be the current font of *target*, as given by that object's `font` attribute.

4. Apply the appropriate step from the following list to determine the value of *direction*:

   ↪ **If the *target* object's font style source node is an element**

   Let *direction* be the directionality of the *target* object's font style source node.

   ↪ **If the *target* object's font style source node is a `Document` and that `Document` has a root**

element child

Let *direction* be the directionality of the *target* object's font style source node's root element child.

↪ **If the *target* object's font style source node is a `Document` and that `Document` has no root element child**

Let *direction* be 'ltr'.

5. Form a hypothetical infinitely-wide CSS line box containing a single inline box containing the text *text*, with all the properties at their initial values except the 'font' property of the inline box set to *font*, the 'direction' property of the inline box set to *direction*, and the 'white-space' property set to 'pre'. [CSS]

6. If *maxWidth* was provided and the hypothetical width of the inline box in the hypothetical line box is greater than *maxWidth* CSS pixels, then change *font* to have a more condensed font (if one is available or if a reasonably readable one can be synthesized by applying a horizontal scale factor to the font) or a smaller font, and return to the previous step.

7. The *anchor point* is a point on the inline box, and the *physical alignment* is one of the values *left*, *right*, and *center*. These variables are determined by the `textAlign` and `textBaseline` values as follows:

   Horizontal position:

   If `textAlign` is `left`
   If `textAlign` is `start` and *direction* is 'ltr'
   If `textAlign` is `end` and *direction* is 'rtl'

   Let the *anchor point*'s horizontal position be the left edge of the inline box, and let *physical alignment* be *left*.

   If `textAlign` is `right`
   If `textAlign` is `end` and *direction* is 'ltr'
   If `textAlign` is `start` and *direction* is 'rtl'

   Let the *anchor point*'s horizontal position be the right edge of the inline box, and let *physical alignment* be *right*.

   If `textAlign` is `center`

   Let the *anchor point*'s horizontal position be halfway between the left and right edges of the inline box, and let *physical alignment* be *center*.

   Vertical position:

   If `textBaseline` is `top`

   Let the *anchor point*'s vertical position be the top of the em box of the first available font of the inline box.

   If `textBaseline` is `hanging`

   Let the *anchor point*'s vertical position be the hanging baseline of the first available font of the inline box.

   If `textBaseline` is `middle`

   Let the *anchor point*'s vertical position be halfway between the bottom and the top of the em box of the first available font of the inline box.

   If `textBaseline` is `alphabetic`

   Let the *anchor point*'s vertical position be the alphabetic baseline of the first available font of the inline box.

   If `textBaseline` is `ideographic`

   Let the *anchor point*'s vertical position be the ideographic baseline of the first available font of the inline box.

   If `textBaseline` is `bottom`

   Let the *anchor point*'s vertical position be the bottom of the em box of the first available font of the inline box.

8. Let *result* be an array constructed by iterating over each glyph in the inline box from left to right (if any), adding to the array, for each glyph, the shape of the glyph as it is in the inline box, positioned on a coordinate space using CSS pixels with its origin is at the *anchor point*.

9. Return *result*, and, for callers that need it, *physical alignment* as the alignment value.

5 Building paths

Each object implementing the `CanvasPathMethods` interface has a path. A **path** has a list of zero or more subpaths. Each subpath consists of a list of one or more points, connected by straight or curved lines, and a flag indicating whether the subpath is closed or not. A closed subpath is one where the last point of the subpath is connected to the first point of the subpath by a straight line. Subpaths with fewer than two points are ignored when painting the path.

When an object implementing the `CanvasPathMethods` interface is created, its path must be initialized to zero subpaths.

Note:

context . `moveTo`(***x***, ***y***)

Creates a new subpath with the given point.

context . `closePath`()

Marks the current subpath as closed, and starts a new subpath with a point the same as the start and end of the newly closed subpath.

context . `lineTo`(***x***, ***y***)

Adds the given point to the current subpath, connected to the previous one by a straight line.

context . `quadraticCurveTo`(***cpx***, ***cpy***, ***x***, ***y***)

Adds the given point to the current subpath, connected to the previous one by a quadratic Bézier curve with the given control point.

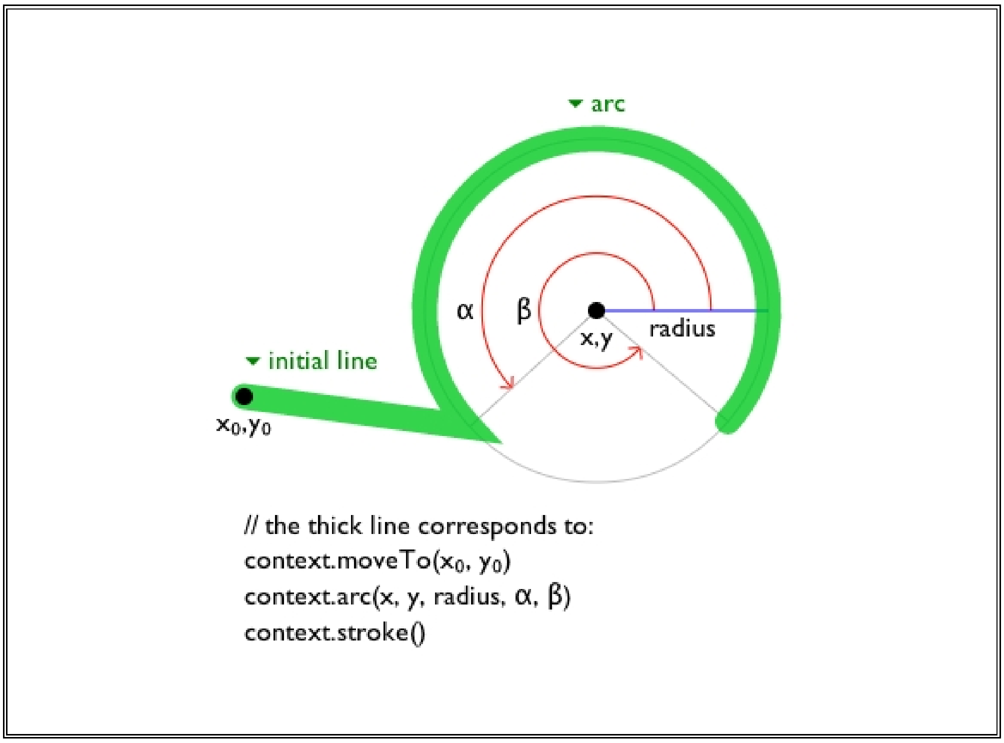
context . `bezierCurveTo`(***cp1x***, ***cp1y***, ***cp2x***, ***cp2y***, ***x***, ***y***)

Adds the given point to the current subpath, connected to the previous one by a cubic Bézier curve with the given control points.

context . `arcTo`(***x1***, ***y1***, ***x2***, ***y2***, ***radius***)

Adds an arc with the given control points and radius to the current subpath, connected to the previous point by a straight line.

Throws an `IndexSizeError` exception if the given radius is negative.



```
// the thick line corresponds to:
context.moveTo(x0, y0)
context.arc(x, y, radius, α, β)
context.stroke()
```

context . `arc`(***x***, ***y***, ***radius***, ***startAngle***, ***endAngle*** [, ***counterclockwise***])

Adds points to the subpath such that the arc described by the circumference of the circle described by the arguments, starting at the given start angle and ending at the given end angle, going in the given direction (defaulting to clockwise), is added to the path, connected to the previous point by a straight line.

Throws an `IndexSizeError` exception if the given radius is negative.

context . `rect`(***x***, ***y***, ***w***, ***h***)

Adds a new closed subpath to the path, representing the given rectangle.

The following methods allow authors to manipulate the paths of objects implementing the `CanvasPathMethods` interface.

For `CanvasRenderingContext2D` objects, the points and lines added to current default path by these methods must be transformed according to the current transformation matrix before they are added to the path.

The **`moveTo(`*`x`*`, `*`y`*`)`** method must create a new subpath with the specified point as its first (and only) point.

When the user agent is to **ensure there is a subpath** for a coordinate (*x*, *y*) on a path, the user agent must check to see if the path has any subpaths, and if it does not, then the user agent must create a new subpath with the point (*x*, *y*) as its first (and only) point, as if the `moveTo()` method had been called.

The **`closePath()`** method must do nothing if the object's path has no subpaths. Otherwise, it must mark the last subpath as closed, create a new subpath whose first point is the same as the previous subpath's first point, and finally add this new subpath to the path.

> **Note:** If the last subpath had more than one point in its list of points, then this is equivalent to adding a straight line connecting the last point back to the first point, thus "closing" the shape, and then repeating the last (possibly implied) `moveTo()` call.

New points and the lines connecting them are added to subpaths using the methods described below. In all cases, the methods only modify the last subpath in the object's path.

The **`lineTo(`*`x`*`, `*`y`*`)`** method must ensure there is a subpath for (*x*, *y*) if the object's path has no subpaths. Otherwise, it must connect the last point in the subpath to the given point (*x*, *y*) using a straight line, and must then add the given point (*x*, *y*) to the subpath.

The **`quadraticCurveTo(`*`cpx`*`, `*`cpy`*`, `*`x`*`, `*`y`*`)`** method must ensure there is a subpath for (*cpx*, *cpy*), and then must connect the last point in the subpath to the given point (*x*, *y*) using a quadratic Bézier curve with control point (*cpx*, *cpy*), and must then add the given point (*x*, *y*) to the subpath. [BEZIER]

The **`bezierCurveTo(`*`cp1x`*`, `*`cp1y`*`, `*`cp2x`*`, `*`cp2y`*`, `*`x`*`, `*`y`*`)`** method must ensure there is a subpath for (*cp1x*, *cp1y*), and then must connect the last point in the subpath to the given point (*x*, *y*) using a cubic Bézier curve with control points (*cp1x*, *cp1y*) and (*cp2x*, *cp2y*). Then, it must add the point (*x*, *y*) to the subpath. [BEZIER]

The **`arcTo(`*`x1`*`, `*`y1`*`, `*`x2`*`, `*`y2`*`, `*`radius`*`)`** method must first ensure there is a subpath for (*x1*, *y1*). Then, the behavior depends on the arguments and the last point in the subpath, as described below.

Negative values for *radius* must cause the implementation to throw an `IndexSizeError` exception.

Let the point (*x0*, *y0*) be the last point in the subpath.

If the point (*x0*, *y0*) is equal to the point (*x1*, *y1*), or if the point (*x1*, *y1*) is equal to the point (*x2*, *y2*), or if the radius *radius* is zero, then the method must add the point (*x1*, *y1*) to the subpath, and connect that point to the previous point (*x0*, *y0*) by a straight line.

Otherwise, if the points (*x0*, *y0*), (*x1*, *y1*), and (*x2*, *y2*) all lie on a single straight line, then the method must add the point (*x1*, *y1*) to the subpath, and connect that point to the previous point (*x0*, *y0*) by a straight line.

Otherwise, let *The Arc* be the shortest arc given by circumference of the circle that has radius *radius*, and that has one point tangent to the half-infinite line that crosses the point (*x0*, *y0*) and ends at the point (*x1*, *y1*), and that has a different point tangent to the half-infinite line that ends at the point (*x1*, *y1*), and crosses the point (*x2*, *y2*). The points at which this circle touches these two lines are called the start and end tangent points respectively. The method must connect the point (*x0*, *y0*) to the start tangent point by a straight line, adding the start tangent point to the subpath, and then must connect the start tangent point to the end tangent point by *The Arc*, adding the end tangent point to the subpath.

The **`arc(`*`x`*`, `*`y`*`, `*`radius`*`, `*`startAngle`*`, `*`endAngle`*`, `*`counterclockwise`*`)`** method draws an arc.

If the context has any subpaths, then the method must add a straight line from the last point in the subpath to the start point of the arc. In any case, it must draw the arc between the start point of the arc and the end point of the arc, and add the start and end points of the arc to the subpath. The arc and its start and end points are defined as follows:

Consider a circle that has its origin at (*x*, *y*), and that has radius *radius*. The points at *startAngle* and *endAngle* this circle's circumference, measured in radians clockwise from the positive x-axis, are the start and end points respectively.

If the *counterclockwise* argument false and *endAngle*-*startAngle* is equal to or greater than 2π, or if the *counterclockwise* argument is *true* and *startAngle*-*endAngle* is equal to or greater than 2π, then the arc is the whole circumference of this circle.

Otherwise, the arc is the path along the circumference of this circle from the start point to the end point, going anti-clockwise if the *counterclockwise* argument is true, and clockwise otherwise. Since the points are on the circle, as opposed to being simply angles from zero, the arc can never cover an angle greater than 2π radians. If the two points are the same, or if the radius is zero, then the arc is defined as being of zero length in both directions.

Negative values for *radius* must cause the implementation to throw an `IndexSizeError` exception.

The **`rect(`*`x`*`, `*`y`*`, `*`w`*`, `*`h`*`)`** method must create a new subpath containing just the four points (*x*, *y*), (*x*+*w*, *y*), (*x*+*w*, *y*+*h*), (*x*, *y*+*h*), with those four points connected by straight lines, and must then mark the subpath as closed. It must then create a new subpath with the point (*x*, *y*) as the only point in the subpath.

6 Transformations

Each `CanvasRenderingContext2D` object has a *current transformation matrix*, as well as methods (described in this section) to manipulate it. When a `CanvasRenderingContext2D` object is created, its transformation matrix must be initialized to the identity transform.

The transformation matrix is applied to coordinates when creating the current path, and when painting text, shapes, and paths, on `CanvasRenderingContext2D` objects.

> **Note:** Most of the API uses `SVGMatrix` objects rather than this API. This API remains mostly for historical reasons.

The transformations must be performed in reverse order.

> **Note:** For instance, if a scale transformation that doubles the width is applied to the canvas, followed by a rotation transformation that rotates drawing operations by a quarter turn, and a rectangle twice as wide as it is tall is then drawn on the canvas, the actual result will be a square.

Note:

context . `scale`(***x***, ***y***)

Changes the transformation matrix to apply a scaling transformation with the given characteristics.

context . `rotate`(***angle***)

Changes the transformation matrix to apply a rotation transformation with the given characteristics. The angle is in radians.

context . `translate`(***x***, ***y***)

Changes the transformation matrix to apply a translation transformation with the given characteristics.

context . `transform`(***a***, ***b***, ***c***, ***d***, ***e***, ***f***)

Changes the transformation matrix to apply the matrix given by the arguments as described below.

context . `setTransform`(***a***, ***b***, ***c***, ***d***, ***e***, ***f***)

Changes the transformation matrix *to* the matrix given by the arguments as described below.

The **`scale(`*`x`*`, `*`y`*`)`** method must add the scaling transformation described by the arguments to the transformation matrix. The *x* argument represents the scale factor in the horizontal direction and the *y* argument represents the scale factor in the vertical direction. The factors are multiples.

The **`rotate(`*`angle`*`)`** method must add the rotation transformation described by the argument to the transformation matrix. The *angle* argument represents a clockwise rotation angle expressed in radians.

The **`translate(`*`x`*`, `*`y`*`)`** method must add the translation transformation described by the arguments to the transformation matrix. The *x* argument represents the translation distance in the horizontal direction and the *y* argument represents the translation distance in the vertical direction. The arguments are in coordinate space units.

The **`transform(`*`a`*`, `*`b`*`, `*`c`*`, `*`d`*`, `*`e`*`, `*`f`*`)`** method must replace the current transformation matrix with the result of multiplying the current transformation matrix with the matrix described by:

$$\begin{matrix} a & c & e \\ b & d & f \\ 0 & 0 & 1 \end{matrix}$$

> **Note:** The arguments *a*, *b*, *c*, *d*, *e*, and *f* are sometimes called *m11*, *m12*, *m21*, *m22*, *dx*, and *dy* or *m11*, *m21*, *m12*, *m22*, *dx*, and *dy*. Care should be taken in particular with the order of the second and third arguments (*b* and *c*) as their order varies from API to API and APIs sometimes use the notation *m12*/*m21* and sometimes *m21*/*m12* for those positions.

The **`setTransform(a, b, c, d, e, f)`** method must reset the current transform to the identity matrix, and then invoke the `transform(a, b, c, d, e, f)` method with the same arguments.

7 Image sources for 2D rendering contexts

This union type allows objects implementing any of the following interfaces to be used as image sources:

- `HTMLImageElement` (`img` elements)
- `HTMLVideoElement` (`video` elements)
- `HTMLCanvasElement` (`canvas` elements)

When a user agent is required to **check the usability of the *image* argument**, where *image* is a `CanvasImageSource` object, the user agent must run these steps, which return either *good*, *bad*, or *aborted*:

1. If the *image* argument is an `HTMLImageElement` object that is in the broken state, then throw an `InvalidStateError` exception, return *aborted*, and abort these steps.
2. If the *image* argument is an `HTMLImageElement` object that is not fully decodable, or if the *image* argument is an `HTMLVideoElement` object whose `readyState` attribute is either `HAVE_NOTHING` or `HAVE_METADATA`, then return *bad* and abort these steps.
3. If the *image* argument is an `HTMLImageElement` object with an intrinsic width or intrinsic height (or both) equal to zero, then return *bad* and abort these steps.
4. If the *image* argument is an `HTMLCanvasElement` object with either a horizontal dimension or a vertical dimension equal to zero, then return *bad* and abort these steps.
5. Return *good*.

When a `CanvasImageSource` object represents an `HTMLImageElement`, the element's image must be used as the source image.

Specifically, when a `CanvasImageSource` object represents an animated image in an `HTMLImageElement`, the user agent must use the default image of the animation (the one that the format defines is to be used when animation is not supported or is disabled), or, if there is no such image, the first frame of the animation, when rendering the image for `CanvasRenderingContext2D` APIs.

When a `CanvasImageSource` object represents an `HTMLVideoElement`, then the frame at the current playback position when the method with the argument is invoked must be used as the source image when rendering the image for `CanvasRenderingContext2D` APIs, and the source image's dimensions must be the intrinsic width and intrinsic height of the media resource (i.e. after any aspect-ratio correction has been applied).

When a `CanvasImageSource` object represents an `HTMLCanvasElement`, the element's bitmap must be used as the source image.

The *image argument* is not origin-clean if it is an `HTMLImageElement` or `HTMLVideoElement` whose origin is not the same as the origin specified by the entry settings object, or if it is an `HTMLCanvasElement` whose bitmap's origin-clean flag is false, or if it is a `CanvasRenderingContext2D` object whose bitmap's origin-clean flag is false.

8 Fill and stroke styles

Note:

***context* . `fillStyle` [= *value*]**

Returns the current style used for filling shapes.

Can be set, to change the fill style.

The style can be either a string containing a CSS color, or a `CanvasGradient` or `CanvasPattern` object. Invalid values are ignored.

***context* . `strokeStyle` [= *value*]**

Returns the current style used for stroking shapes.

Can be set, to change the stroke style.

The style can be either a string containing a CSS color, or a `CanvasGradient` or `CanvasPattern` object. Invalid values are ignored.

The **`fillStyle`** attribute represents the color or style to use inside shapes, and the **`strokeStyle`** attribute represents the color or style to use for the lines around the shapes.

Both attributes can be either strings, `CanvasGradient`s, or `CanvasPattern`s. On setting, strings must be parsed as CSS <color> values and the color assigned, and `CanvasGradient` and `CanvasPattern` objects must be assigned themselves [CSSCOLOR]. If the value is a string but cannot be parsed as a CSS <color> value, or is neither a string, a `CanvasGradient`, nor a `CanvasPattern`, then it must be ignored, and the attribute must retain its previous value. If the new value is a `CanvasPattern` object that is marked as not origin-clean, then the bitmap's origin-clean flag must be set to false.

When set to a `CanvasPattern` or `CanvasGradient` object, the assignment is live, meaning that changes made to the object after the assignment do affect subsequent stroking or filling of shapes.

On getting, if the value is a color, then the serialization of the color must be returned. Otherwise, if it is not a color but a `CanvasGradient` or `CanvasPattern`, then the respective object must be returned. (Such objects are opaque and therefore only useful for assigning to other attributes or for comparison to other gradients or patterns.)

The **serialization of a color** for a color value is a string, computed as follows: if it has alpha equal to 1.0, then the string is a lowercase six-digit hex value, prefixed with a "#" character (U+0023 NUMBER SIGN), with the first two digits representing the red component, the next two digits representing the green component, and the last two digits representing the blue component, the digits being in the range 0-9 a-f (U+0030 to U+0039 and U+0061 to U+0066). Otherwise, the color value has alpha less than 1.0, and the string is the color value in the CSS `rgba()` functional-notation format: the literal string `rgba` (U+0072 U+0067 U+0062 U+0061) followed by a U+0028 LEFT PARENTHESIS, a base-ten integer in the range 0-255 representing the red component (using digits 0-9, U+0030 to U+0039, in the shortest form possible), a literal U+002C COMMA and U+0020 SPACE, an integer for the green component, a comma and a space, an integer for the blue component, another comma and space, a U+0030 DIGIT ZERO, if the alpha value is greater than zero then a U+002E FULL STOP (representing the decimal point), if the alpha value is greater than zero then one or more digits in the range 0-9 (U+0030 to U+0039) representing the fractional part of the alpha, and finally a U+0029 RIGHT PARENTHESIS. User agents must express the fractional part of the alpha value, if any, with the level of precision necessary for the alpha value, when reparsed, to be interpreted as the same alpha value.

When the context is created, the `fillStyle` and `strokeStyle` attributes must initially have the string value `#000000`.

When the value is a color, it must not be affected by the transformation matrix when used to draw on the canvas.

There are two types of gradients, linear gradients and radial gradients, both represented by objects implementing the opaque `CanvasGradient` interface.

Once a gradient has been created (see below), stops are placed along it to define how the colors are distributed along the gradient. The color of the gradient at each stop is the color specified for that stop. Between each such stop, the colors and the alpha component must be linearly interpolated over the RGBA space without premultiplying the alpha value to find the color to use at that offset. Before the first stop, the color must be the color of the first stop. After the last stop, the color must be the color of the last stop. When there are no stops, the gradient is transparent black.

Note:

***gradient* . `addColorStop`(*offset*, *color*)**

Adds a color stop with the given color to the gradient at the given offset. 0.0 is the offset at one end of the gradient, 1.0 is the offset at the other end.

Throws an `IndexSizeError` exception if the offset is out of range. Throws a `SyntaxError` exception if the color cannot be parsed.

***gradient* = *context* . `createLinearGradient`(*x0*, *y0*, *x1*, *y1*)**

Returns a `CanvasGradient` object that represents a linear gradient that paints along the line given by the coordinates represented by the arguments.

***gradient* = *context* . `createRadialGradient`(*x0*, *y0*, *r0*, *x1*, *y1*, *r1*)**

Returns a `CanvasGradient` object that represents a radial gradient that paints along the cone given by the circles represented by the arguments.

If either of the radii are negative, throws an `IndexSizeError` exception.

The `addColorStop(`*offset*`, `*color*`)` method on the `CanvasGradient` interface adds a new stop to a gradient. If the *offset* is less than 0 or greater than 1 then an `IndexSizeError` exception must be thrown. If the *color* cannot be parsed as a CSS <color> value, then a `SyntaxError` exception must be thrown. Otherwise, the gradient must have a new stop placed, at offset *offset* relative to the whole gradient, and with the color obtained by parsing *color* as a CSS <color> value. If multiple stops are added at the same offset on a gradient, they must be placed in the order added, with the first one closest to the start of the gradient, and each subsequent one infinitesimally further along towards the end point (in effect causing all but the first and last stop added at each point to be ignored).

The `createLinearGradient(`*x0*`, `*y0*`, `*x1*`, `*y1*`)` method takes four arguments that represent the start point (*x0*, *y0*) and end point (*x1*, *y1*) of the gradient. The method must return a linear `CanvasGradient` initialized with the specified line.

Linear gradients must be rendered such that all points on a line perpendicular to the line that crosses the start and end points have the color at the point where those two lines cross (with the colors coming from the interpolation and extrapolation described above). The points in the linear gradient must be transformed as described by the current transformation matrix when rendering.

If *x0* = *x1* and *y0* = *y1*, then the linear gradient must paint nothing.

The `createRadialGradient(`*x0*`, `*y0*`, `*r0*`, `*x1*`, `*y1*`, `*r1*`)` method takes six arguments, the first three representing the start circle with origin (*x0*, *y0*) and radius *r0*, and the last three representing the end circle with origin (*x1*, *y1*) and radius *r1*. The values are in coordinate space units. If either of *r0* or *r1* are negative, an `IndexSizeError` exception must be thrown. Otherwise, the method must return a radial `CanvasGradient` initialized with the two specified circles.

Radial gradients must be rendered by following these steps:

1. If $x_0 = x_1$ and $y_0 = y_1$ and $r_0 = r_1$, then the radial gradient must paint nothing. Abort these steps.

2. Let $x(\omega) = (x_1 - x_0)\omega + x_0$

Let $y(\omega) = (y_1 - y_0)\omega + y_0$

Let $r(\omega) = (r_1 - r_0)\omega + r_0$

Let the color at ω be the color at that position on the gradient (with the colors coming from the interpolation and extrapolation described above).

3. For all values of ω where $r(\omega) > 0$, starting with the value of ω nearest to positive infinity and ending with the value of ω nearest to negative infinity, draw the circumference of the circle with radius $r(\omega)$ at position ($x(\omega)$, $y(\omega)$), with the color at ω, but only painting on the parts of the canvas that have not yet been painted on by earlier circles in this step for this rendering of the gradient.

> **Note:** This effectively creates a cone, touched by the two circles defined in the creation of the gradient, with the part of the cone before the start circle (0.0) using the color of the first offset, the part of the cone after the end circle (1.0) using the color of the last offset, and areas outside the cone untouched by the gradient (transparent black).

The resulting radial gradient must then be transformed as described by the current transformation matrix when rendering.

Gradients must be painted only where the relevant stroking or filling effects requires that they be drawn.

Patterns are represented by objects implementing the opaque `CanvasPattern` interface.

Note:

***pattern* = *context* . `createPattern`(*image* , *repetition*)**

Returns a `CanvasPattern` object that uses the given image and repeats in the direction(s) given by the *repetition* argument.

The allowed values for *repetition* are "`repeat`" (both directions), "`repeat-x`" (horizontal only), "`repeat-y`" (vertical only), and "`no-repeat`" (neither). If the *repetition* argument is empty, the value `repeat` is used.

If the image has no image data, throws an `InvalidStateError` exception. If the second argument isn't one of the allowed values, throws a `SyntaxError` exception. If the image isn't yet fully decoded, then the method returns null.

To create objects of this type, the **`createPattern(`*`image`*`, `*`repetition`*`)`** method is used. When the method is invoked, the user agent must run the following steps:

1. Let *image* be the first argument and *repetition* be the second argument.

2. Check the usability of the image argument. If this returns *aborted*, then an exception has been thrown and the method doesn't return anything; abort these steps. If it returns *bad*, then return null and abort these steps. Otherwise it returns *good*; continue with these steps.

3. If *repetition* is the empty string, let it be "`repeat`".

4. If *repetition* is not a case-sensitive match for one of "`repeat`", "`repeat-x`", "`repeat-y`", or "`no-repeat`", throw a *SyntaxError* exception and abort these steps.

5. Create a new `CanvasPattern` object with the image *image* and the repetition behavior given by *repetition*.

6. If the image argument is not origin-clean, then mark the `CanvasPattern` object as ***not origin-clean***.

7. Return the `CanvasPattern` object.

Modifying this *image* after calling the `createPattern()` method must not affect the pattern.

Patterns must be painted so that the top left of the first image is anchored at the origin of the coordinate space, and images are then repeated horizontally to the left and right, if the `repeat-x` string was specified, or vertically up and down, if the `repeat-y` string was specified, or in all four directions all over the canvas, if the `repeat` string was specified, to create the repeated pattern that is used for rendering. The images are not scaled by this process; one CSS pixel of the image must be painted on one coordinate space unit in generating the repeated pattern. When rendered, however, patterns must actually be painted only where the stroking or filling effect requires that they be drawn, and the repeated pattern must be affected by the current transformation matrix. Pixels not covered by the repeating pattern (if the `repeat` string was not specified) must be transparent black.

If the original image data is a bitmap image, the value painted at a point in the area of the repetitions is computed by filtering the original image data. The user agent may use any filtering algorithm (for example bilinear interpolation or nearest-neighbor). When the filtering algorithm requires a pixel value from outside the original image data, it must instead use the value from wrapping the pixel's coordinates to the original image's dimensions. (That is, the filter uses 'repeat' behavior, regardless of the value of *repetition*.)

If a radial gradient or repeated pattern is used when the transformation matrix is singular, the resulting style must be transparent black (otherwise the gradient or pattern would be collapsed to a point or line, leaving the other pixels undefined). Linear gradients and solid colors always define all points even with singular transformation matrices.

9 Drawing rectangles to the canvas

There are three methods that immediately draw rectangles to the bitmap. They each take four arguments; the first two give the *x* and *y* coordinates of the top left of the rectangle, and the second two give the width *w* and height *h* of the rectangle, respectively.

The current transformation matrix must be applied to the following four coordinates, which form the path that must then be closed to get the specified rectangle: (*x*, *y*), (*x*+*w*, *y*), (*x*+*w*, *y*+*h*), (*x*, *y*+*h*).

Shapes are painted without affecting the current default path, and are subject to the clipping region, and, with the exception of `clearRect()`, also shadow effects, global alpha, and global composition operators.

Note:

context . `clearRect`(***x***, ***y***, ***w***, ***h***)

Clears all pixels on the canvas in the given rectangle to transparent black.

context . `fillRect`(***x***, ***y***, ***w***, ***h***)

Paints the given rectangle onto the canvas, using the current fill style.

context . `strokeRect`(***x***, ***y***, ***w***, ***h***)

Paints the box that outlines the given rectangle onto the canvas, using the current stroke style.

The **`clearRect(`*`x`*`, `*`y`*`, `*`w`*`, `*`h`*`)`** method must run the following steps:

1. Let *pixels* be the set of pixels in the specified rectangle that also intersect the current clipping region.
2. Clear the pixels in *pixels* to fully transparent black, erasing any previous image.
3. Clear regions that cover the pixels in *pixels* in the `canvas` element.

> **Note:** If either height or width are zero, this method has no effect, since the set of pixels would be empty.

The **`fillRect(`*`x`*`, `*`y`*`, `*`w`*`, `*`h`*`)`** method must paint the specified rectangular area using the `fillStyle`. If either height or width are zero, this method has no effect.

The **`strokeRect(`*`x`*`, `*`y`*`, `*`w`*`, `*`h`*`)`** method must take the result of tracing the path described below, using the `CanvasRenderingContext2D` object's line styles, and fill it with the `strokeStyle`.

If both *w* and *h* are zero, the path has a single subpath with just one point (*x*, *y*), and no lines, and this method thus has no effect (the trace a path algorithm returns an empty path in that case).

If just one of either *w* or *h* is zero, then the path has a single subpath consisting of two points, with coordinates (*x*, *y*) and (*x*+*w*, *y*+*h*), in that order, connected by a single straight line.

Otherwise, the path has a single subpath consisting of four points, with coordinates (*x*, *y*), (*x*+*w*, *y*), (*x*+*w*, *y*+*h*), and (*x*, *y*+*h*), connected to each other in that order by straight lines.

10 Drawing text to the canvas

Note:

context **.** `fillText`**(** ***text*****,** ***x*****,** ***y*** **[,** ***maxWidth*** **])**
context **.** `strokeText`**(** ***text*****,** ***x*****,** ***y*** **[,** ***maxWidth*** **])**

> Fills or strokes (respectively) the given text at the given position. If a maximum width is provided, the text will be scaled to fit that width if necessary.

metrics **=** ***context*** **.** `measureText`**(** ***text*** **)**

> Returns a `TextMetrics` object with the metrics of the given text in the current font.

metrics **.** `width`

> Returns the advance width of the text that was passed to the `measureText()` method.

The `CanvasRenderingContext2D` interface provides the following methods for rendering text directly to the canvas.

The **`fillText()`** and **`strokeText()`** methods take three or four arguments, *text*, *x*, *y*, and optionally *maxWidth*, and render the given *text* at the given (*x*, *y*) coordinates ensuring that the text isn't wider than *maxWidth* if specified, using the current `font`, `textAlign`, and `textBaseline` values. Specifically, when the methods are called, the user agent must run the following steps:

1. Run the text preparation algorithm, passing it *text*, the `CanvasRenderingContext2D` object, and, if the *maxWidth* argument was provided, that argument. Let *glyphs* be the result.

2. Move all the shapes in *glyphs* to the right by *x* CSS pixels and down by *y* CSS pixels.

3. Paint the shapes given in *glyphs*, as transformed by the current transformation matrix, with each CSS pixel in the coordinate space of *glyphs* mapped to one coordinate space unit.

   For `fillText()`, `fillStyle` must be applied to the shapes and `strokeStyle` must be ignored. For `strokeText()`, the reverse holds: `strokeStyle` must be applied to the result of tracing the shapes using the `CanvasRenderingContext2D` object for the line styles, and `fillStyle` must be ignored.

   These shapes are painted without affecting the current path, and are subject to shadow effects, global alpha, the clipping region, and global composition operators.

4. If the text preparation algorithm used a font that has an origin that is not the same as the origin specified by the entry settings object (even if "using a font" means just checking if that font has a particular glyph in it before falling back to another font), then set the bitmap's origin-clean flag to false.

The **`measureText()`** method takes one argument, *text*. When the method is invoked, the user agent must run the text preparation algorithm, pass a new TextMetrics object with its attributes set as described in the following list. If doing these measurements requires using a font that has an origin that is not the same as that of the `Document` object that owns the `canvas` element (even if "using a font" means just checking if that font has a particular glyph in it before falling back to another font), then the method must throw a `SecurityError` exception. Otherwise, it must return the new `TextMetrics` object. [CSS]

`width` **attribute**
> The width of that inline box, in CSS pixels. (The text's advance width.)

If doing these measurements requires using a font that has an origin that is not the same as that of the `Document` object that owns the `canvas` element (even if "using a font" means just checking if that font has a particular glyph in it before falling back to another font), then the method must throw a `SecurityError` exception. Otherwise, it must return the new `TextMetrics` object. [CSS]

The `TextMetrics` interface is used for the objects returned from `measureText()`. It has one attribute, **`width`**, which is set by the `measureText()` method.

> **Note:** Glyphs rendered using `fillText()` and `strokeText()` can spill out of the box given by the font size (the em square size) and the width returned by `measureText()` (the text width). This version of the specification does not provide a way to obtain the bounding box dimensions of the text. If the text is to be rendered and removed, care needs to be taken to replace the entire area of the canvas that the clipping region covers, not just the box given by the em square height and measured text width.

> **Note:** A future version of the 2D context API may provide a way to render fragments of documents, rendered using CSS, straight to the canvas. This would be provided in preference to a dedicated way of doing multiline layout.

11 Drawing paths to the canvas

The context always has a **current default path**. There is only one current path, it is not part of the drawing state. The current path is a path, as described above.

> **Note:**
>
> *context* . `beginPath`()
>
> Resets the current path.
>
> *context* . `fill`()
>
> Fills the subpaths of the current path or the given path with the current fill style.
>
> *context* . `stroke`()
>
> Strokes the subpaths of the current path or the given path with the current stroke style.
>
> *context* . `drawFocusIfNeeded`(*element*)
>
> Informs the user of the canvas location for the fallback element, based on the current path. If the given element has focus, draws a focus outline around the current path following the platform or user agent conventions for focus outlines as defined by the user agent.
>
> *context* . `clip`()
>
> Further constrains the clipping region to the current path.
>
> *context* . `isPointInPath`(*x*, *y*)
>
> Returns true if the given point is in the current path.

The `beginPath()` method must empty the list of subpaths in the context's current path so that the it once again has zero subpaths.

The `fill()` method must fill all the subpaths of the current path, using `fillStyle`, and using the non-zero winding number rule. Open subpaths must be implicitly closed when being filled (without affecting the actual subpaths).

> **Note:** Thus, if two overlapping but otherwise independent subpaths have opposite windings, they cancel out and result in no fill. If they have the same winding, that area just gets painted once.

The `stroke()` method must trace the path, using the `CanvasRenderingContext2D` object for the line styles, and then fill the combined stroke area using the `strokeStyle` attribute.

> **Note:** As a result of how the algorithm to trace a path is defined, overlapping parts of the paths in one stroke operation are treated as if their union was what was painted.

> **Note:** The stroke style is affected by the transformation during painting, even if the path is the current default path.

Paths, when filled or stroked, must be painted without affecting the current path, and must be subject to shadow effects, global alpha, the clipping region, and global composition operators.

Zero-length line segments must be pruned before stroking a path. Empty subpaths must be ignored.

The `drawFocusIfNeeded(`*`element`*`)` method, when invoked, must run the following steps:

1. If the current path has zero subpaths, then abort these steps.

2. If *element* is not focused or is not a descendant of the element with whose context the method is associated, then abort these steps.

3. If the user has requested the use of particular focus outlines (e.g. high-contrast focus outlines), or if the *element* would have a focus outline drawn around it, then draw a focus outline of the appropriate style along the intended path, following platform conventions.

   > **Note:** Some platforms only draw focus outlines around elements that have been focused from the keyboard, and not those focused from the mouse. Other platforms simply don't draw focus outlines around some elements at all unless relevant accessibility features are enabled. This API is intended to follow these conventions. User agents that implement distinctions based on the manner in which the element was focused are encouraged to classify focus driven by the `focus()` method based on the kind of user interaction event from which the call was triggered (if any).

   The focus outline should not be subject to the shadow effects, the global alpha, or the global composition operators, but *should* be subject to the clipping region. When the focus area is clipped by the canvas element, only the visual representation of the focus outline is clipped to the clipping region.

   If the focus area is not on the screen, then scroll the focus outline into view when it receives focus.

4. Inform the user of the location given by the path. The full location of the corresponding fallback element is passed to the accessibility API, if supported. User agents may wait until the next time the event loop reaches its "update the rendering" step to inform the user.

> **Note:** "Inform the user", as used in this section, could mean calling a system accessibility API, which would notify assistive technologies such as magnification tools. To properly drive magnification based on a focus change, a system accessibility API driving a screen magnifier needs the bounds for the newly focused object. The methods above are intended to enable this by allowing the user agent to report the bounding box of the path used to render the focus outline as the bounds of the *element* element passed as an argument, if that element is focused, and the bounding box of the area to which the user agent is scrolling as the bounding box of the current selection.

The **`clip()`** method must create a new **clipping region** by calculating the intersection of the current clipping region and the area described by the path, using the non-zero winding number rule. Open subpaths must be implicitly closed when computing the clipping region, without affecting the actual subpaths. The new clipping region replaces the current clipping region.

When the context is initialized, the clipping region must be set to the rectangle with the top left corner at (0,0) and the width and height of the coordinate space.

The **`isPointInPath()`** method must return true if the point given by the *x* and *y* coordinates passed to the method, when treated as coordinates in the canvas coordinate space unaffected by the current transformation, is inside the intended path as determined by the non-zero winding number rule; and must return false otherwise. Points on the path itself must be considered to be inside the path. If either of the arguments is infinite or NaN, then the method must return false.

12 Drawing images to the canvas

To draw images onto the canvas, the **`drawImage`** method can be used.

This method can be invoked with three different sets of arguments:

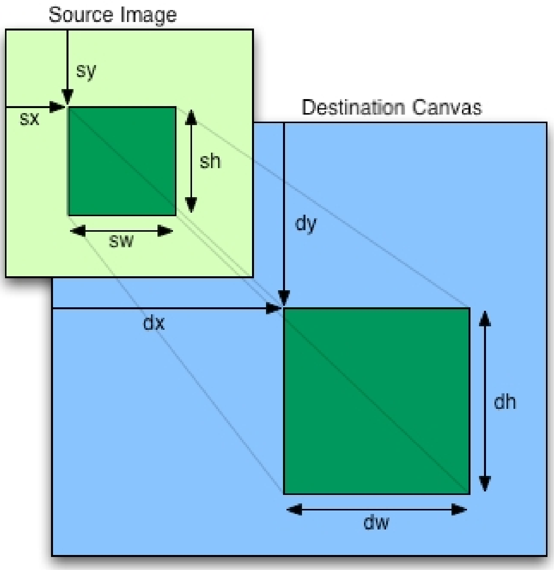
- `drawImage(` *`image`* `,` *`dx`* `,` *`dy`* `)`
- `drawImage(` *`image`* `,` *`dx`* `,` *`dy`* `,` *`dw`* `,` *`dh`* `)`
- `drawImage(` *`image`* `,` *`sx`* `,` *`sy`* `,` *`sw`* `,` *`sh`* `,` *`dx`* `,` *`dy`* `,` *`dw`* `,` *`dh`* `)`

Each of those three can take either an `HTMLImageElement`, an `HTMLCanvasElement`, or an `HTMLVideoElement` for the *image* argument.

Note:

context **. `drawImage`(*image* , *dx* , *dy*)**
context **. `drawImage`(*image* , *dx* , *dy* , *dw* , *dh*)**
context **. `drawImage`(*image* , *sx* , *sy* , *sw* , *sh* , *dx* , *dy* , *dw* , *dh*)**

Draws the given image onto the canvas. The arguments are interpreted as follows:



If the first argument isn't an `img`, `canvas`, or `video` element, throws a `TypeMismatchError` exception. If the image has no image data, throws an `InvalidStateError` exception. If the one of the source rectangle dimensions is zero, throws an `IndexSizeError` exception. If the image isn't yet fully decoded, then nothing is drawn.

When the `drawImage()` method is invoked, the user agent must run the following steps:

1. Check the usability of the *image* argument. If this returns *aborted*, then an exception has been thrown and the method doesn't return anything; abort these steps. If it returns *bad*, then abort these steps without drawing anything. Otherwise it returns *good*; continue with these steps.

2. Establish the source and destination rectangles as follows:

   If not specified, the *dw* and *dh* arguments must default to the values of *sw* and *sh*, interpreted such that one CSS pixel in the image is treated as one unit in the bitmap's coordinate space. If the *sx* , *sy* , *sw*, and *sh* arguments are not specified, they must default to 0, 0, the image's intrinsic width in image pixels, and the image's intrinsic height in image pixels, respectively. If the image has no intrinsic dimensions, the *concrete object size* must be used instead, as determined using the CSS "Concrete Object Size Resolution" algorithm, with the *specified size* having neither a definite width nor height, nor any additional constraints, the object's intrinsic properties being those of the *image* argument, and the default object size being the size of the bitmap. [CSSIMAGES]

The source rectangle is the rectangle whose corners are the four points (*sx*, *sy*), (*sx*+*sw*, *sy*), (*sx*+*sw*, *sy*+*sh*), (*sx*, *sy*+*sh*).

The destination rectangle is the rectangle whose corners are the four points (*dx*, *dy*), (*dx*+*dw*, *dy*), (*dx*+*dw*, *dy*+*dh*), (*dx*, *dy*+*dh*).

When the source rectangle is outside the source image, the source rectangle must be clipped to the source image and the destination rectangle must be clipped in the same proportion.

> **Note:** When the destination rectangle is outside the destination image (the bitmap), the pixels that land outside the bitmap are discarded, as if the destination was an infinite canvas whose rendering was clipped to the dimensions of the bitmap.

3. If one of the *sw* or *sh* arguments is zero, abort these steps. Nothing is painted.

4. Paint the region of the *image* argument specified by the source rectangle on the region of the rendering context's bitmap specified by the destination rectangle, after applying the current transformation matrix to the destination rectangle.

   The image data must be processed in the original direction, even if the dimensions given are negative.

   > **Note:** This specification does not define the algorithm to use when scaling the image, if necessary.

   > **Note:** When a canvas is drawn onto itself, the drawing model requires the source to be copied before the image is drawn back onto the canvas, so it is possible to copy parts of a canvas onto overlapping parts of itself.

   If the original image data is a bitmap image, the value painted at a point in the destination rectangle is computed by filtering the original image data. The user agent may use any filtering algorithm (for example bilinear interpolation or nearest-neighbor). When the filtering algorithm requires a pixel value from outside the original image data, it must instead use the value from the nearest edge pixel. (That is, the filter uses 'clamp-to-edge' behaviour.) When the filtering algorithm requires a pixel value from outside the source rectangle but inside the original image data, then the value from the original image data must be used.

   > **Note:** Thus, scaling an image in parts or in whole will have the same effect. This does mean that when sprites coming from a single sprite sheet are to be scaled, adjacent images in the sprite sheet can interfere. This can be avoided by ensuring each sprite in the sheet is surrounded by a border of transparent black, or by copying sprites to be scaled into temporary `canvas` elements and drawing the scaled sprites from there.

   Images are painted without affecting the current path, and are subject to shadow effects, global alpha, the clipping region, and global composition operators.

5. If the *image argument* is not origin-clean, set the bitmap's origin-clean flag to false.

Images are painted without affecting the current path, and are subject to shadow effects, global alpha, the clipping region, and global composition operators.

13 Hit regions

Each `canvas` element whose primary context is a `CanvasRenderingContext2D` object must have a **hit region list** associated with its bitmap.

The hit region list is a list of hit regions.

Each **hit region** consists of the following information:

- A **path** on the `canvas` element's bitmap for which this region is responsible.
- A **bounding circumference** on the `canvas` element's bitmap that surrounds the hit region's path as it stood when it was created.
- Optionally, a non-empty string representing an **ID** for distinguishing the region from others.
- Optionally, a control.

  A **control** is a reference to an `Element` node, to which, in certain conditions, the user agent will route events, and from which the user agent will determine the state of the hit region for the purposes of accessibility tools. (The control is ignored when it is not a descendant of the canvas element.)

Note:

***context* . `addHitRegion`(*options*)**

Adds a hit region to the canvas bitmap based on the current default path. The argument is an object with the following members:

`id` (default empty string)

The ID to use for this region. This is used in `MouseEvent` events on the `canvas` (`event.region`) and as a way to reference this region in later calls to `addHitRegion()`.

`control` (default null)

An element (that is a descendant of the `canvas`) to which events are to be routed, and which accessibility tools are to use as a surrogate for describing and interacting with this region.

Hit regions can be used for a variety of purposes:

- With an ID, they can make hit detection easier by having the user agent check which region the mouse is over and include the ID in the mouse events.
- With a control, they can make routing events to DOM elements automatic, allowing e.g. clicks on a canvas to automatically submit a form via a `button` element.

> **Note:** While both ID and control are optional, when calling addHitRegion, at least one of the two needs to be present to create a hit region.

***context* . `removeHitRegion`(*id*)**

Removes a hit region from the canvas bitmap. The argument is the ID of a region added using `addHitRegion()`.

The path that was covered by this region are effectively cleared by this operation, leaving the regions non-interactive. In particular, regions that occupied the same path before the removed regions were added, do not resume their previous roles.

***context* . `clearHitRegions`()**

Removes all hit regions from the canvas bitmap.

The paths that were covered by these regions are effectively cleared by this operation, leaving all regions non-interactive.

The region identified by the ID *ID* in a bitmap *bitmap* is the value returned by the following algorithm (which can return a hit region or nothing):

1. If *ID* is null, return nothing and abort these steps.
2. Let *list* be the hit region list associated with *bitmap*.
3. If there is a hit region in *list* whose ID is a case-sensitive match for *ID*, then return that hit region and abort these steps.
4. Otherwise, return nothing.

The region representing the control *control* for a bitmap *bitmap* is the value returned by the following algorithm (which can return a hit region or nothing):

1. If *control* is null, return nothing and abort these steps.
2. Let *list* be the hit region list associated with *bitmap*.
3. If there is a hit region in *list* whose control is *control*, then return that hit region and abort these steps.

4. Otherwise, return nothing.

The control represented by a region *region* for a `canvas` element *ancestor* is the value returned by the following algorithm (which can return an element or nothing):

1. If *region* has no control, return nothing and abort these steps.
2. Let *control* be *region*'s control.
3. If *control* is not a descendant of *ancestor*, then return nothing and abort these steps.
4. Otherwise, return *control*.

The region for a pixel *pixel* on a bitmap *bitmap* is the value returned by the following algorithm (which can return a hit region or nothing):

1. Let *list* be the hit region list associated with *bitmap*.
2. If there is a hit region in *list* whose path contains *pixel*, then return that hit region and abort these steps.
3. Otherwise, return nothing.

When the **`addHitRegion()`** method is invoked, the user agent must run the following steps:

1. Let *arguments* be the dictionary object provided as the method's argument.
2. Let *source path* be the `CanvasRenderingContext2D` object's current default path.
3. Let *specified pixels* be the pixels contained in *source path*.
4. Remove from *specified pixels* any pixels not contained within the clipping region.
5. If the *arguments* object's `id` member is an empty string, let it be null instead.
6. If the *arguments* object's `id` member is null and the *arguments* object's `control` member is null, throw a `NotSupportedError` exception and abort these steps.
7. If the *arguments* object's `id` member is not null, then let *previous region for this ID* be the region identified by the ID given by the `id` member's value in this `canvas` element. If the `id` member is null or no such region currently exists, let *previous region for this ID* be null.
8. If the *specified pixels* has no pixels, throw a `NotSupportedError` exception and abort these steps.
9. Let *region* be a newly created hit region, with its information configured as follows:

   Hit region's path
   : The *specified pixels*.

   Hit region's bounding circumference
   : A user-agent-defined shape that wraps the pixels contained in *source path*. (In the simplest case, this can just be the bounding rectangle; this specification allows it to be any shape in order to allow other interfaces.)

   Hit region's ID
   : If the *arguments* object's `id` member is not null: the value of the `id` member. Otherwise, *region* has no id.

   Hit region's control
   : If the *arguments* object's `control` member is not null: the value of the `control` member. Otherwise, *region* has no control.

10. If the *arguments* object's `control` member is not null, then let *previous region for the control* be the region representing the control given by the `control` member's value for this `canvas`

element, if any. If the `control` member is null or no such region currently exists, let *previous region for the control* be null.

11. If there is a *previous region with this control*, remove it from the `canvas` element's hit region list.
12. If the arguments object's `control` member is not null, inform the user of the location of the region representing the `control` given by the control member's value for this `canvas` element, if any. The full location of the corresponding fallback element, pertaining to the `control`, as represented by the region is passed to the accessibility API, if supported.
13. If there is a *previous region with this ID*, remove it from the `canvas` element's hit region list.
14. Add *region* to the `canvas` element's hit region list.

When the **`removeHitRegion()`** method is invoked, the user agent must run the following steps:

1. Let *region* be the region identified by the ID given by the method's argument in this `canvas` element, if any. If no such region currently exists, abort these steps.

   > **Note:** If the method's argument is an empty string, then no region will match.

2. Remove *region* from the `canvas` element's hit region list.

When the **`clearHitRegions()`** method is invoked, the user agent must run the following steps:

1. Remove all *hit regions* from the `canvas` element and clear the element's hit region list. If no regions currently exist, abort these steps.

> **Note:** Calling `clearRect()` is a way to clear all or some hit regions. Calling clearHitRegions() removes all hit regions and clears the hit region list. The hit region list itself is also reset when the rendering context is reset. For example, when a `CanvasRenderingContext2D` object is bound to or unbound from a `canvas`, or the dimensions of the bitmap are changed.

The `MouseEvent` interface is extended to support hit regions:

IDL

```
partial interface MouseEvent {
  readonly attribute DOMString? region;
};

partial dictionary MouseEventInit {
  DOMString? region;
};
```

Note:

event . **`region`**

If the mouse was over a hit region, then this returns the hit region's ID if it has one.

Otherwise, returns null.

The **`region`** attribute on `MouseEvent` objects must return the value it was initialized to. When the object is created, this attribute must be initialized to null. It represents the hit region's ID if the mouse was over a hit region when the event was fired.

When a `MouseEvent` is to be fired at a `canvas` element by the user agent in response to a pointing device action, if the `canvas` element has a hit region list, the user agent must instead follow these steps. If these steps say to *act as normal*, that means that the event must be fired as it would have had these requirements not been applied.

1. If the pointing device is not indicating a pixel on the canvas, *act as normal* and abort these steps.

2. If the canvas element has no hit region list, act as normal and abort these steps.
3. Let pixel be the pixel indicated by the pointing device.
4. Let region be the hit region that is the region for the pixel *pixel* on this canvas element's bitmap, if any.
5. Let *id* be the *region*'s ID, if any.
6. If there is an *id*, then initialize the event object's `region` attribute to *id*.
7. Dispatch the event, but with the updated event object as given in the above steps.

> **Note:** This approach simplifies event handling by not re-targeting the event. The event is dispatched as normal once the event.region attribute is initialized to the active hit region's ID. The event is received by the canvas element allowing the author to define the behavior of the event.

User agents are encouraged to make use of the information present in a `canvas` element's hit region list to improve the accessibility of `canvas` elements.

Each hit region should be handled in a fashion equivalent to a node in a virtual DOM tree rooted at the `canvas` element. The hierarchy of this virtual DOM tree must match the hierarchy of the hit regions. For each node in such a DOM tree, the hit region's bounding circumference gives the region of the screen to use when representing the node (if appropriate).

The semantics of a hit region for the purposes of this virtual DOM tree are those of the hit region's control, if it has one.

For the purposes of accessibility tools, when an element *C* is a descendant of a `canvas` element and there is a region representing the control *C* for that `canvas` element, then the element's position relative to the document should be presented as if it was that region in the `canvas` element's virtual DOM tree.

14 Pixel manipulation

Note:

imagedata **=** ***context*** **.** **`createImageData`(*sw*, *sh*)**

Returns an `ImageData` object with the given dimensions in CSS pixels (which might map to a different number of actual device pixels exposed by the object itself). All the pixels in the returned object are transparent black.

imagedata **=** ***context*** **.** **`createImageData`(*imagedata*)**

Returns an `ImageData` object with the same dimensions as the argument. All the pixels in the returned object are transparent black.

imagedata **=** ***context*** **.** **`getImageData`(*sx*, *sy*, *sw*, *sh*)**

Returns an `ImageData` object containing the image data for the given rectangle of the canvas.

Throws an `IndexSizeError` exception if the either of the width or height arguments are zero.

The data will be returned with one pixel of image data for each coordinate space unit on the canvas (ignoring transforms).

imagedata **.** **`width`**
imagedata **.** **`height`**

Returns the actual dimensions of the data in the `ImageData` object, in device pixels.

imagedata **.** **`data`**

Returns the one-dimensional array containing the data in RGBA order, as integers in the range 0 to 255.

context **.** **`putImageData`(*imagedata*, *dx*, *dy* [, *dirtyX*, *dirtyY*, *dirtyWidth*, *dirtyHeight*])**

Paints the data from the given `ImageData` object onto the canvas. If a dirty rectangle is provided, only the pixels from that rectangle are painted.

The `globalAlpha` and `globalCompositeOperation` attributes, as well as the shadow attributes, are ignored for the purposes of this method call; pixels in the canvas are replaced wholesale, with no composition, alpha blending, no shadows, etc.

Throws a `NotSupportedError` exception if any of the arguments are not finite.

The **`createImageData()`** method is used to instantiate new blank `ImageData` objects. When the method is invoked with two arguments *sw* and *sh*, it must return an `ImageData` object representing a rectangle with a width in CSS pixels equal to the absolute magnitude of *sw* and a height in CSS pixels equal to the absolute magnitude of *sh*. When invoked with a single *imagedata* argument, it must return an `ImageData` object representing a rectangle with the same dimensions as the `ImageData` object passed as the argument. The `ImageData` object returned must be filled with transparent black.

The **`getImageData(`*sx*`,` *sy*`,` *sw*`,` *sh*`)`** method must, if the bitmap of the `canvas` element's *origin-clean* flag is set to false, throw a `SecurityError` exception; otherwise, it must return an `ImageData` object representing the underlying pixel data for the area of the canvas denoted by the rectangle whose corners are the four points (*sx*, *sy*), (*sx*+*sw*, *sy*), (*sx*+*sw*, *sy*+*sh*), (*sx*, *sy*+*sh*), in canvas coordinate space units. Pixels outside the canvas must be returned as transparent black. Pixels must be returned as non-premultiplied alpha values.

If any of the arguments to `createImageData()` or `getImageData()` are infinite or NaN, the method must instead throw a `NotSupportedError` exception. If either the *sw* or *sh* arguments are zero, the method must instead throw an `IndexSizeError` exception.

`ImageData` objects must be initialized so that their **`width`** attribute is set to *w*, the number of physical device pixels per row in the image data, their **`height`** attribute is set to *h*, the number of rows in the image data, and their **`data`** attribute is initialized to a `Uint8ClampedArray` object. The

`Uint8ClampedArray` object must use a Canvas Pixel `ArrayBuffer` for its storage, and must have a zero start offset and a length equal to the length of its storage, in bytes. The Canvas Pixel `ArrayBuffer` must contain the image data. At least one pixel's worth of image data must be returned. [TYPEDARRAY]

A **Canvas Pixel `ArrayBuffer`** is an `ArrayBuffer` that whose data is represented in left-to-right order, row by row top to bottom, starting with the top left, with each pixel's red, green, blue, and alpha components being given in that order for each pixel. Each component of each device pixel represented in this array must be in the range 0..255, representing the 8 bit value for that component. The components must be assigned consecutive indices starting with 0 for the top left pixel's red component. [TYPEDARRAY]

The **`putImageData(`*`imagedata`*`,`*`dx`*`,`*`dy`*`,`*`dirtyX`*`,`*`dirtyY`*`,`*`dirtyWidth`*`,`*`dirtyHeight`*`)`** method writes data from `ImageData` structures back to the canvas.

If any of the arguments to the method are infinite or NaN, the method must throw a `NotSupportedError` exception.

When the last four arguments are omitted, they must be assumed to have the values 0, 0, the `width` member of the *imagedata* structure, and the `height` member of the *imagedata* structure, respectively.

When invoked with arguments that do not, per the last few paragraphs, cause an exception to be thrown, the `putImageData()` method must act as follows:

1. Let dx_{device} be the x-coordinate of the device pixel in the underlying pixel data of the canvas corresponding to the dx coordinate in the canvas coordinate space.

   Let dy_{device} be the y-coordinate of the device pixel in the underlying pixel data of the canvas corresponding to the dy coordinate in the canvas coordinate space.

2. If $dirtyWidth$ is negative, let $dirtyX$ be $dirtyX+dirtyWidth$, and let $dirtyWidth$ be equal to the absolute magnitude of $dirtyWidth$.

   If $dirtyHeight$ is negative, let $dirtyY$ be $dirtyY+dirtyHeight$, and let $dirtyHeight$ be equal to the absolute magnitude of $dirtyHeight$.

3. If $dirtyX$ is negative, let $dirtyWidth$ be $dirtyWidth+dirtyX$, and let $dirtyX$ be zero.

   If $dirtyY$ is negative, let $dirtyHeight$ be $dirtyHeight+dirtyY$, and let $dirtyY$ be zero.

4. If $dirtyX+dirtyWidth$ is greater than the `width` attribute of the *imagedata* argument, let $dirtyWidth$ be the value of that `width` attribute, minus the value of $dirtyX$.

   If $dirtyY+dirtyHeight$ is greater than the `height` attribute of the *imagedata* argument, let $dirtyHeight$ be the value of that `height` attribute, minus the value of $dirtyY$.

5. If, after those changes, either $dirtyWidth$ or $dirtyHeight$ is negative or zero, stop these steps without affecting the canvas.

6. Otherwise, for all integer values of x and y where $dirtyX \le x < dirtyX+dirtyWidth$ and $dirtyY \le y < dirtyY+dirtyHeight$, copy the four channels of the pixel with coordinate (x, y) in the *imagedata* data structure to the pixel with coordinate ($dx_{device}+x$, $dy_{device}+y$) in the underlying pixel data of the canvas.

The handling of pixel rounding when the specified coordinates do not exactly map to the device coordinate space is not defined by this specification, except that the following must result in no visible changes to the rendering:

```
context.putImageData(context.getImageData(x, y, w, h), p, q);
```

...for any value of x, y, w, and h and where p is the smaller of x and the sum of x and w, and q is the smaller of y and the sum of y and h; and except that the following two calls:

```
context.createImageData(w, h);
context.getImageData(0, 0, w, h);
```

...must return `ImageData` objects with the same dimensions, for any value of *w* and *h*. In other words, while user agents may round the arguments of these methods so that they map to device pixel boundaries, any rounding performed must be performed consistently for all of the `createImageData()`, `getImageData()` and `putImageData()` operations.

> **Note:** This implies that the data returned by `getImageData()` is at the resolution of the canvas backing store. This is likely to not be one device pixel to each CSS pixel if the display used is a high resolution display.

> **Note:** Due to the lossy nature of converting to and from premultiplied alpha color values, pixels that have just been set using `putImageData()` might be returned to an equivalent `getImageData()` as different values.

The current path, transformation matrix, shadow attributes, global alpha, the clipping region, and global composition operator must not affect the `getImageData()` and `putImageData()` methods.

Code Example:

In the following example, the script generates an `ImageData` object so that it can draw onto it.

```
// canvas is a reference to a <canvas> element
var context = canvas.getContext('2d');

// create a blank slate
var data = context.createImageData(canvas.width, canvas.height);

// create some plasma
FillPlasma(data, 'green'); // green plasma

// add a cloud to the plasma
AddCloud(data, data.width/2, data.height/2); // put a cloud in the middle

// paint the plasma+cloud on the canvas
context.putImageData(data, 0, 0);

// support methods
function FillPlasma(data, color) { ... }
function AddCloud(data, x, y) { ... }
```

Code Example:

Here is an example of using `getImageData()` and `putImageData()` to implement an edge detection filter.

```
<!DOCTYPE HTML>
<html>
 <head>
  <title>Edge detection demo</title>
  <script>
   var image = new Image();
   function init() {
     image.onload = demo;
     image.src = "image.jpeg";
   }
   function demo() {
     var canvas = document.getElementsByTagName('canvas')[0];
     var context = canvas.getContext('2d');

     // draw the image onto the canvas
     context.drawImage(image, 0, 0);

     // get the image data to manipulate
     var input = context.getImageData(0, 0, canvas.width, canvas.height);

     // get an empty slate to put the data into
     var output = context.createImageData(canvas.width, canvas.height);

     // alias some variables for convenience
     // notice that we are using input.width and input.height here
     // as they might not be the same as canvas.width and canvas.height
     // (in particular, they might be different on high-res displays)
     var w = input.width, h = input.height;
     var inputData = input.data;
     var outputData = output.data;

     // edge detection
     for (var y = 1; y < h - 1; y += 1) {
       for (var x = 1; x < w - 1; x += 1) {
         for (var c = 0; c < 3; c += 1) {
           var i = (y*w + x)*4 + c;
           outputData[i] = 127 + -inputData[i - w*4 - 4] -   inputData[i - w*4] -
inputData[i - w*4 + 4] +
                                  -inputData[i - 4]       + 8*inputData[i]       -
inputData[i + 4] +
                                  -inputData[i + w*4 - 4] -   inputData[i + w*4] -
inputData[i + w*4 + 4];
         }
         outputData[(y*w + x)*4 + 3] = 255; // alpha
       }
     }

     // put the image data back after manipulation
     context.putImageData(output, 0, 0);
   }
  </script>
 </head>
 <body onload="init()">
  <canvas></canvas>
 </body>
</html>
```

15 Compositing

Note:

context **.** **`globalAlpha`** **[=** ***value*** **]**

Returns the current alpha value applied to rendering operations.

Can be set, to change the alpha value. Values outside of the range 0.0 .. 1.0 are ignored.

context **.** **`globalCompositeOperation`** **[=** ***value*** **]**

Returns the current composition operation, from the list below.

Can be set, to change the composition operation. Unknown values are ignored.

All drawing operations are affected by the global compositing attributes, `globalAlpha` and `globalCompositeOperation`.

The **`globalAlpha`** attribute gives an alpha value that is applied to shapes and images before they are composited onto the canvas. The value must be in the range from 0.0 (fully transparent) to 1.0 (no additional transparency). If an attempt is made to set the attribute to a value outside this range, including Infinity and Not-a-Number (NaN) values, the attribute must retain its previous value. When the context is created, the `globalAlpha` attribute must initially have the value 1.0.

The **`globalCompositeOperation`** attribute sets how shapes and images are drawn onto the existing bitmap, once they have had `globalAlpha` and the current transformation matrix applied. It must be set to a value from the following list. In the descriptions below, the source image, *A*, is the shape or image being rendered, and the destination image, *B*, is the current state of the bitmap.

`source-atop`

A atop *B*. Display the source image wherever both images are opaque. Display the destination image wherever the destination image is opaque but the source image is transparent. Display transparency elsewhere.

`source-in`

A in *B*. Display the source image wherever both the source image and destination image are opaque. Display transparency elsewhere.

`source-out`

A out *B*. Display the source image wherever the source image is opaque and the destination image is transparent. Display transparency elsewhere.

`source-over` **(default)**

A over *B*. Display the source image wherever the source image is opaque. Display the destination image elsewhere.

`destination-atop`

B atop *A*. Same as `source-atop` but using the destination image instead of the source image and vice versa.

`destination-in`

B in *A*. Same as `source-in` but using the destination image instead of the source image and vice versa.

`destination-out`

B out *A*. Same as `source-out` but using the destination image instead of the source image and vice versa.

`destination-over`

B over *A*. Same as `source-over` but using the destination image instead of the source image and vice versa.

`lighter`

A plus *B*. Display the sum of the source image and destination image, with color values approaching 255 (100%) as a limit.

`copy`

A (*B* is ignored). Display the source image instead of the destination image.

`xor`

A xor *B*. Exclusive OR of the source image and destination image.

`vendorName-operationName`
Vendor-specific extensions to the list of composition operators should use this syntax.

The operators in the above list must be treated as described by the Porter-Duff operator given at the start of their description (e.g. *A* over *B*). They are to be applied as part of the drawing model, at which point the clipping region is also applied. (Without a clipping region, these operators act on the whole bitmap with every operation.) [PORTERDUFF]

These values are all case-sensitive — they must be used exactly as shown. User agents must not recognize values that are not a case-sensitive match for one of the values given above.

On setting, if the user agent does not recognize the specified value, it must be ignored, leaving the value of `globalCompositeOperation` unaffected.

When the context is created, the `globalCompositeOperation` attribute must initially have the value `source-over`.

16 Shadows

All drawing operations are affected by the four global shadow attributes.

Note:

context . `shadowColor` [= ***value***]

Returns the current shadow color.

Can be set, to change the shadow color. Values that cannot be parsed as CSS colors are ignored.

context . `shadowOffsetX` [= ***value***]
context . `shadowOffsetY` [= ***value***]

Returns the current shadow offset.

Can be set, to change the shadow offset. Values that are not finite numbers are ignored.

context . `shadowBlur` [= ***value***]

Returns the current level of blur applied to shadows.

Can be set, to change the blur level. Values that are not finite numbers greater than or equal to zero are ignored.

The `shadowColor` attribute sets the color of the shadow.

When the context is created, the `shadowColor` attribute initially must be fully-transparent black.

On getting, the serialization of the color must be returned.

On setting, the new value must be parsed as a CSS <color> value and the color assigned. If the value cannot be parsed as a CSS <color> value then it must be ignored, and the attribute must retain its previous value. [CSSCOLOR]

The `shadowOffsetX` and `shadowOffsetY` attributes specify the distance that the shadow will be offset in the positive horizontal and positive vertical distance respectively. Their values are in coordinate space units. They are not affected by the current transformation matrix.

When the context is created, the shadow offset attributes must initially have the value `0`.

On getting, they must return their current value. On setting, the attribute being set must be set to the new value, except if the value is infinite or NaN, in which case the new value must be ignored.

The `shadowBlur` attribute specifies the level of the blurring effect. (The units do not map to coordinate space units, and are not affected by the current transformation matrix.)

When the context is created, the `shadowBlur` attribute must initially have the value `0`.

On getting, the attribute must return its current value. On setting the attribute must be set to the new value, except if the value is negative, infinite or NaN, in which case the new value must be ignored.

Shadows are only drawn if the opacity component of the alpha component of the color of `shadowColor` is non-zero and at leasty one of `shadowBlur`, `shadowOffsetX`, or `shadowOffsetY` is non-zero.

It is likely that this will change: browser vendors have indicated an interest in changing the processing model for shadows such that they only draw when the composition operator is "source-over" (the default). Read more...

When shadows are drawn, they must be rendered as follows:

1. Let *A* be an infinite transparent black bitmap on which the source image for which a shadow is being created has been rendered.

2. Let *B* be an infinite transparent black bitmap, with a coordinate space and an origin identical to *A*.

3. Copy the alpha channel of *A* to *B*, offset by `shadowOffsetX` in the positive *x* direction, and `shadowOffsetY` in the positive *y* direction.

4. If `shadowBlur` is greater than 0:

    1. Let *σ* be half the value of `shadowBlur`.

    2. Perform a 2D Gaussian Blur on *B*, using *σ* as the standard deviation.

    User agents may limit values of *σ* to an implementation-specific maximum value to avoid exceeding hardware limitations during the Gaussian blur operation.

5. Set the red, green, and blue components of every pixel in *B* to the red, green, and blue components (respectively) of the color of `shadowColor`.

6. Multiply the alpha component of every pixel in *B* by the alpha component of the color of `shadowColor`.

7. The shadow is in the bitmap *B*, and is rendered as part of the drawing model described below.

If the current composition operation is `copy`, shadows effectively won't render (since the shape will overwrite the shadow).

17 Drawing model

When a shape or image is painted, user agents must follow these steps, in the order given (or act as if they do):

1. Render the shape or image onto an infinite transparent black bitmap, creating image *A*, as described in the previous sections. For shapes, the current fill, stroke, and line styles must be honored, and the stroke must itself also be subjected to the current transformation matrix.
2. When shadows are drawn, render the shadow from image *A*, using the current shadow styles, creating image *B*.
3. When shadows are drawn, multiply the alpha component of every pixel in *B* by `globalAlpha`.
4. When shadows are drawn, composite *B* within the clipping region over the current canvas bitmap using the current composition operator.
5. Multiply the alpha component of every pixel in *A* by `globalAlpha`.
6. Composite *A* within the clipping region over the current canvas bitmap using the current composition operator.

18 Best practices

This section is non-normative.

When a canvas is interactive, authors should include focusable elements in the element's fallback content corresponding to each focusable part of the canvas.

To indicate which focusable part of the canvas is currently focused, authors should use the `drawFocusIfNeeded()` method, passing it the element for which an outline is being drawn. This method only draws the focus outline if the element is focused, so that it can simply be called whenever drawing the element, without checking whether the element is focused or not first.

Authors should avoid implementing text editing controls using the `canvas` element. Doing so has a large number of disadvantages:

- Mouse placement of the caret has to be reimplemented.
- Keyboard movement of the caret has to be reimplemented (possibly across lines, for multiline text input).
- Scrolling of the text field has to be implemented (horizontally for long lines, vertically for multiline input).
- Native features such as copy-and-paste have to be reimplemented.
- Native features such as spell-checking have to be reimplemented.
- Native features such as drag-and-drop have to be reimplemented.
- Native features such as page-wide text search have to be reimplemented.
- Native features specific to the user, for example custom text services, have to be reimplemented. This is close to impossible since each user might have different services installed, and there is an unbounded set of possible such services.
- Bidirectional text editing has to be reimplemented.
- For multiline text editing, line wrapping has to be implemented for all relevant languages.
- Text selection has to be reimplemented.
- Dragging of bidirectional text selections has to be reimplemented.
- Platform-native keyboard shortcuts have to be reimplemented.
- Platform-native input method editors (IMEs) have to be reimplemented.
- Undo and redo functionality has to be reimplemented.
- Accessibility features such as magnification following the caret or selection have to be reimplemented.

This is a huge amount of work, and authors are most strongly encouraged to avoid doing any of it by instead using the `input` element, the `textarea` element, or the `contenteditable` attribute.

19 Examples

This section is non-normative.

> **Code Example:**
>
> Here is an example of a script that uses canvas to draw pretty glowing lines.

```
<canvas width="800" height="450"></canvas>
<script>

 var context = document.getElementsByTagName('canvas')[0].getContext('2d');

 var lastX = context.canvas.width * Math.random();
 var lastY = context.canvas.height * Math.random();
 var hue = 0;
 function line() {
   context.save();
   context.translate(context.canvas.width/2, context.canvas.height/2);
   context.scale(0.9, 0.9);
   context.translate(-context.canvas.width/2, -context.canvas.height/2);
   context.beginPath();
   context.lineWidth = 5 + Math.random() * 10;
   context.moveTo(lastX, lastY);
   lastX = context.canvas.width * Math.random();
   lastY = context.canvas.height * Math.random();
   context.bezierCurveTo(context.canvas.width * Math.random(),
                         context.canvas.height * Math.random(),
                         context.canvas.width * Math.random(),
                         context.canvas.height * Math.random(),
                         lastX, lastY);

   hue = hue + 10 * Math.random();
   context.strokeStyle = 'hsl(' + hue + ', 50%, 50%)';
   context.shadowColor = 'white';
   context.shadowBlur = 10;
   context.stroke();
   context.restore();
 }
 setInterval(line, 50);

 function blank() {
   context.fillStyle = 'rgba(0,0,0,0.1)';
   context.fillRect(0, 0, context.canvas.width, context.canvas.height);
 }
 setInterval(blank, 40);

</script>
```

References

All references are normative unless marked "Non-normative".

[BEZIER]
Courbes à poles, P. de Casteljau. INPI, 1959.

[CSS]
Cascading Style Sheets Level 2 Revision 1 (URL: http://www.w3.org/TR/CSS/), B. Bos, T. Çelik, I. Hickson, H. Lie. W3C.

[CSSCOLOR]
CSS Color Module Level 3 (URL: http://www.w3.org/TR/css3-color/), T. Çelik, C. Lilley, L. Baron. 7 June 2011. W3C Recommendation.

[CSSFONTS]
CSS Fonts Module Level 3 (URL: http://www.w3.org/TR/css3-fonts/), J. Daggett. W3C.

[CSSIMAGES]
CSS Image Values and Replaced Content Module Level 3 (URL: http://www.w3.org/TR/css3-images/), E. Etemad, T. Atkins. W3C.

[CSSOM]
Cascading Style Sheets Object Model (CSSOM) (URL: http://www.w3.org/TR/cssom/), S. Pieters, G. Adams. W3C.

[HTML]
Ian Hickson; Robin Berjon; Steve Faulkner; Travis Leithead; Erika Doyle Navara; Edward O'Connor; Silvia Pfeiffer. *HTML5*. 28 October 2014. W3C Recommendation. URL: http://www.w3.org/TR/html5/

[PORTERDUFF]
Compositing Digital Images (URL: http://keithp.com/~keithp/porterduff/p253-porter.pdf), T. Porter, T. Duff. In *Computer graphics*, volume 18, number 3, pp. 253-259. ACM Press, July 1984.

[TYPEDARRAY]
Typed Array Specification (URL: https://www.khronos.org/registry/typedarray/specs/latest/), D. Herman, K. Russell. Khronos.

[WEBIDL]
Web IDL (URL: http://www.w3.org/TR/WebIDL-1/), Cameron McCormack, Boris Zbarsky, Yves Lafon, Travis Leithead. W3C.