Topics

Future Smartphone Concept with Flexible Display Offering New UX

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Recently, foldable and flexible displays have been developed and announced by several display manufacturers [1], and devices equipped with such displays will be seen in the smartphone market in the coming years. Some smartphones on the market today already have displays that curve around the edges [2], and many patents for flexible smartphone display technologies have been filed and published.

In light of this trend, NTT DOCOMO has been considering the future possibilities of these flexible display technologies, and has conceived a new rollable type flexible smartphone display. In addition, we have also developed a User Interface (UI) technology that changes size by expanding and retracting the rollable display.

This article describes the basic ideas and the motivation behind the rollable type smartphone concept, and also describes development (prototyping) of the UI technology, which aims to offer new User eXperiences (UXs)*1.

In this development, we utilized the "foldable display®*2" [3] provided by Semiconductor Energy Laboratory Co., Ltd. as the flexible display panel (Table 1).

1) Objective of This Development

This development focused on achieving a future-oriented device concept and smartphone UI to offer an attractive UX that will enable users to imagine the promise and wonder of future mobile communication services.

2) Study of Device Concept Design

The flexible display can be folded, twisted and rolled. In studying the flexible display device concept, we thought that the device should:

- Maximize advantages and features of the flexible display,
- Offer a view into the future with the sense of promise and surprise,

Table 1 Foldable display specifications

Display size	8.7 inch
Resolution	1,920 × 1,080 pix
Foldable radius of curvature	2 mm
Repeated folding	100,000 folds or more*

*With radius of curvature of 2 mm.

*1 UX: A general term for the experiences gained through the use or consumption of certain products or services.

*2 foldable display®: A registered trademark of Semiconductor Energy Laboratory Co., Ltd.

- Be practical for ease of development and handling.

As a result of the above studies and taking potential usability improvements into consideration, we came up with two promising concepts - the tri-fold type and the rollable type, as described below.

(1) As shown in **Figure 1**, the tri-fold type can be folded to a third of its size to become a normal smartphone or expanded to its full size to become a tablet device.

(2) As shown in **Figure 2**, the rollable type smartphone can be retracted to the size of a normal smartphone or freely extended from the smartphone size to a tablet size.

On comparing the above two types, we chose the rollable type for the prototyping, as it more closely met our UI/UX development aims.

3) UI Technology Development for the Rollable Type Smartphone

As mentioned, the rollable type concept typically offers two device sizes, smartphone or tablet, and also enables users to enjoy any display size they like between the two. Hence, to create attractive and convenient UXs for this future smartphone concept, we came up with a new UI technology to display content and its layout dynamically to fit the varied display size (**Figure 3**).

- Installation of a potentiometer*3

To achieve the above idea, we attached a potentiometer to the scrolling rod of the flexible display panel to sense how much the display panel is rolled up, which enables calculation of the size of the display.

- Applying Responsive Web Design

With the flexible optimized UI design, it is crucial that display content fit the varying display size. Hence, we decided to leverage Responsive Web Design technology with HyperText Markup Language 5 (HTML5)*4 and Cascading Style Sheets 3 (CSS3)*5 since they are already

*3 Potentiometer: An element that senses the amount of rotation and movement.

*4 HTML5: The 5th and current version of the HTML standard markup language used for structuring and presenting content on the World Wide Web.

*5 CSS3: The level 3 version of the Cascading Style Sheets language used for describing the presentation of a document written in a markup language.

Figure 1 Tri-fold type

Figure 2 Rollable type

widely used. In Web browsers on PCs, Responsive Web Design changes the content size and layout to fit the width of the Web browser window size. Thus, we adapted this technology for the aforementioned variable size of this rollable type smartphone flexible display.

- Flow for displaying content

The following describes the operation of components in the device, and the flow for displaying content on the rollable device.

(a) Calculation of the display size of the rollable device

The amount of display expansion/retraction is sensed by the potentiometer in the scrolling rod of the display panel, and the row data is fed to the UI software (**Figure 4** (1)).

If the sensed data exceeds a certain threshold, the UI software calculates the display size from the sensed data value and the diameter of the wound up display panel

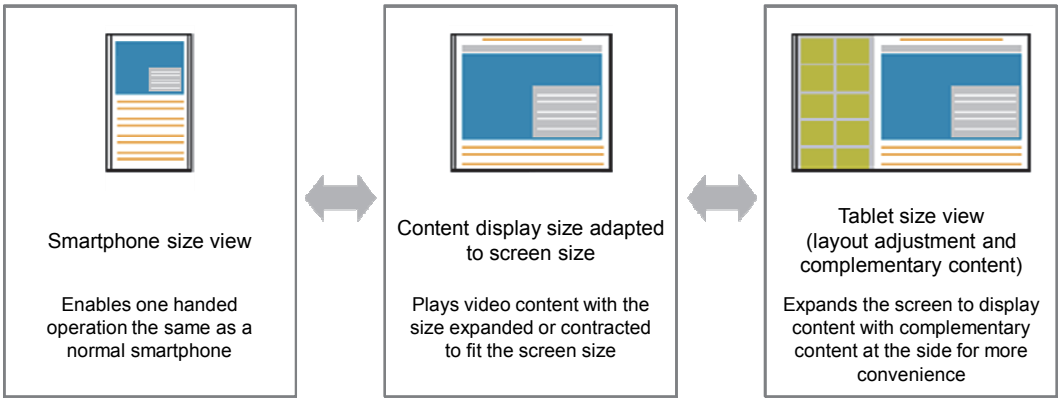

Figure 3 Flexible UI optimized for the display size

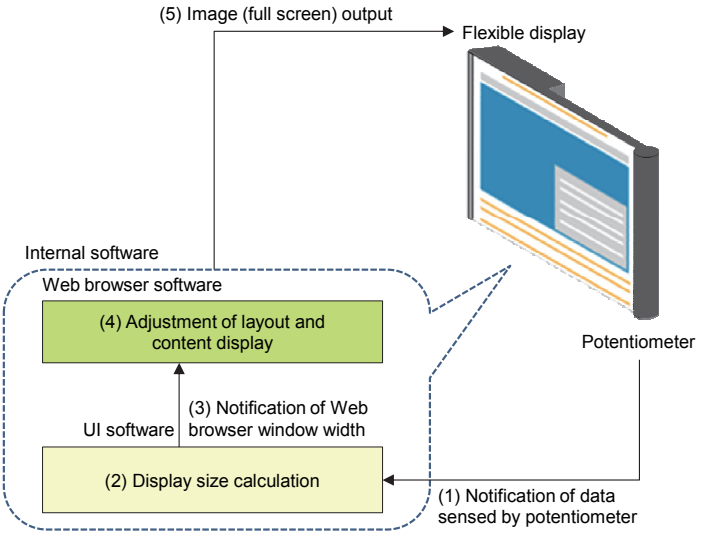

Figure 4 UI adjustment mechanisms

(Fig. 4 (2)), and then the calculated display size is fed to the Web browser as the width of Web browser window size (Fig. 4 (3)).

(b) Adjustment of content layout and display

Because most of content and Web browsers support the Responsive Web Design function, the layout and the display of the content can be adjusted to fit the width of the Web browser window ((Fig. 4 (4)).

(c) Display on the flexible display

After the above adjustment, the Web browser window is output with the window width matched to the size of the flat part of the flexible display, which is fed from the UI software as mentioned above (Fig. 4 (5)). By repeating (a) to (c) above, the device can display content by changing the content size to match the screen size of the rollable display as it is extended or retracted.

With the above, we successfully developed a UI that optimally and dynamically displays content to fit the variable display size (**Photo 1**).

Through the above development, we achieved a prototype*6 of a rollable flexible display device concept that can be held in the hand, and by developing UI technology optimized for this concept device, we achieved a new, attractive and convenient UX that gives the user the sense of the promise and wonder of the mobile communications services of the future.

To commercialize smartphones with this flexible display, robustness of the device (drop resistance, etc.) and the flexible display (scratch hardness, cover film solution, etc.) must be studied in consideration of usage in various scenes.

In addition to the above studies, we will be engaging in further studies to offer even more attractive

*6 Prototype: An early sample, model, or release of a product to test and evaluate a concept.

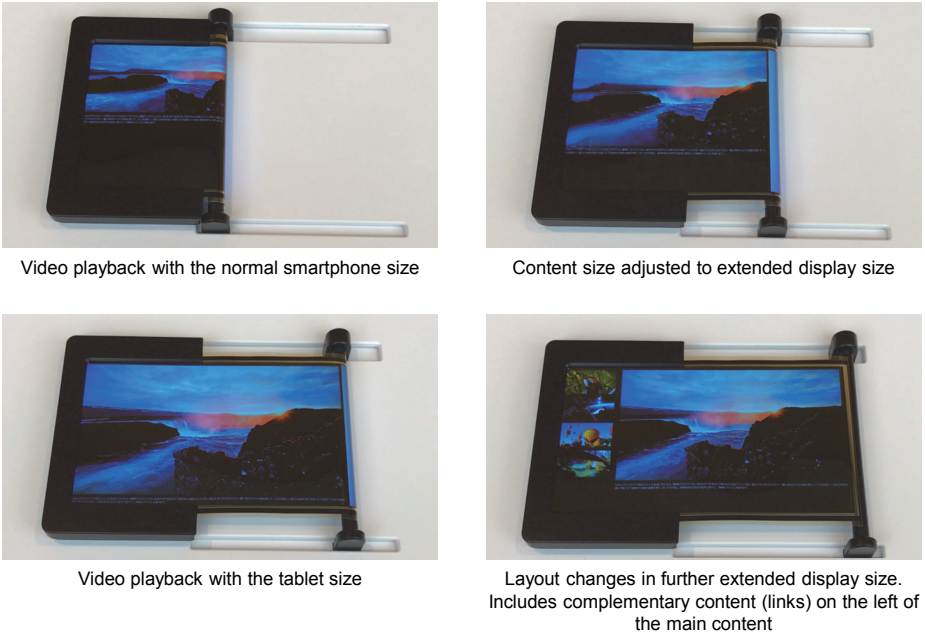

Photo 1 Developed prototype

and convenient UXs to provide promising and surprising services to users.

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