

ZBaby: Android application for pregnancy due date, fetus development simulation and weight gain during pregnancy

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Abstract—For awareness of becoming parents, this paper proposes the development of Z-Baby as an android application to calculate the pregnancy due date, fetus development simulation, weight gain during pregnancy and the amount of calorie in needs. Pregnancy due date is calculated based on user defined data which is the last menstruation. Next, user can view the simulation of 3D fetus development with description week by week using OpenGL ES. Then the weight gain during pregnancy is calculated from the BMI based on the specification by IOM 2009 while allowing a user to manage her weight gain as well. Updated weight data were plotted dynamically using Android Plot API. Daily calorie requirement can be calculated during pregnancy by Harris-Benedict Equation to maintain the appropriated weight for healthy baby without overeating. Other available functions are recording photos & data in monthly basis, locating mom's position on Google map to find the nearest hospital located on the map. For accuracy testing, Z-Baby has been compared to other software packages which have the same functions. Z-Baby is now available for free in Google Play.

Keywords—Fetus development, Weight gain during pregnancy, Calorie requirements, OpenGL ES, Android plot API.

I. INTRODUCTION

A. Learning about pregnancy

Mobile phones or tablets have become useful tools for pregnant women. Parents could look through things such as the pregnancy due date and pregnancy follow up in weekly basis to track down their baby's weekly development, weight gain during pregnancy and so on. There are some mobile applications for pregnancy available in the market such as:

- Mobile Pregnancy [1] can determine the birth date.
- Pregnancy Weight Gain Calculator- SureBaby by CX Interactive [2] shows the appropriate weight during pregnancy.

- My Pregnancy Today by baby center [3] can show the fetal development images and watch what's happening inside the womb with 3D animations. Similar to Z-Baby, but different in terms of Z-Baby shows the fetal growth in 3D each week and user can rotate and view to see the baby in other direction
- iPregnancy by Gregory P. Moore. [4] Price: 3.99 USD. This app has been awarded Best Pregnancy Planner by Parent Magazine, due to its comprehensive components that address every part of a woman's pregnancy experience, from conception right through to naming the baby. But only a preview of 2D-3D ultrasound data is shown at each week of pregnancy.
- Sprout Pregnancy Essentials by Med ART Studios [5] Price: 3.99 USD can create and display 3D models of the developing fetus. The model can rotate at any direction to get more detail but it is available only for iOS.

The available applications can provide parents a bit of knowledge to start making the appropriate decisions for parents to take care their baby during pregnancy.

B. 3D graphics on mobile platforms

The creation of Three-dimensional (3D) scenes in real time using mobile devices is becoming more and more usual. 3D graphics on these devices is challenging due to at least two factors that are drastically different from PC systems with graphics cards. First of all, they have very small displays, and second, they have very small amounts of resources for rendering [6]. Thus, when designing 3D virtual environment for mobile devices, the developer should be extremely careful when using memory resources. Fortunately, OpenGL ES (Open Graphics Library for Embedded Systems) is available for free as a standard 3D graphics API for embedded systems makes it easy and affordable to offer a variety of advanced 3D graphics and games across all major mobile and embedded

platforms. OpenGL ES is a low-level, lightweight API for advanced embedded graphics using well-defined subset profiles of OpenGL. It provides a low-level applications programming interface (API) between software applications and hardware or software graphics engines [7][8], and it has also been incorporated as a part of iPhone4 SDK [9]. Therefore OpenGL ES has been applied for 3D visualization rendering of the fetal development.

C. Using GPS and locating in Google map.

Most Android devices allow to determine the current geo location. This can be done via a GPS (Global Positioning System) module, via cell tower triangulation or via wifi networks. Android contains the android location package which provides the API to determine the current geo position. For more information, there is a tutorial which explained in Android Location API - Tutorial [10].

For display map, Google Maps is one of the many applications bundled with the Android platform. The new Google Maps Android API v2 [11] has offer an interactive, feature-rich maps to users in developing android application. However, during the period of Z-Baby developing, Google Maps Android API v1.0 was applied which is now no longer available. Therefore, we are not going to describe this section in the implementation.

II. IMPLEMENTATION

A. Pregnancy Due Date

To calculate the due date for delivery baby, the first day of the last menstruation is required and compared to the current date. The result of comparison is the week and day pregnancy. The duration of pregnancy is typically 40 weeks from the first day of the woman's last period. Therefore, the first day of the woman's last period plus 40 weeks is in use to calculate the pregnancy due date with the result has shown on the screen as in Fig. 1.

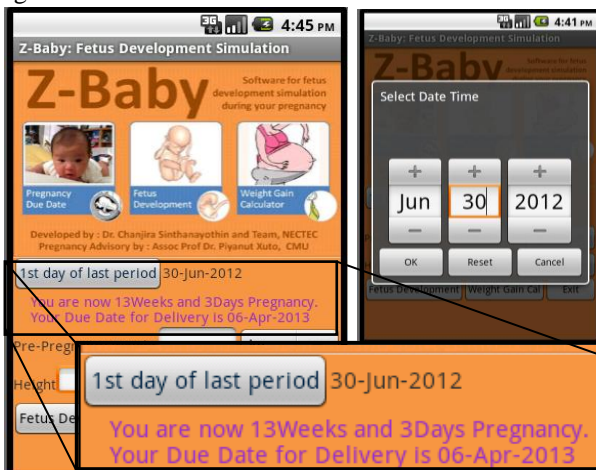


Fig. 1. Show pregnancy due date calculation.

B. Fetus Development Simulation

For fetus development simulation, the 3D models of a baby within the womb ranged from 2 weeks to 42 weeks were

prepared [12]. Since mobile devices have limited memory processing, therefore all 40 models were captured in 7 different views at 256 x 256 pixels for each image. These images will be in use for displaying the fetus development in different directions. Furthermore, OpenGL ES library was applied for quick displaying texture mapping the same as the technique for Gallery3D [13] due to the fact that mobile devices have limited amounts of resources for rendering as shown in Fig. 2. Users are allowed to interact by touching screen or press button to see the fetus in different directions.



Fig. 2. Weekly fetus development simulation

C. Weight Gain During Pregnancy

For calculating weight gain during pregnancy, Z-Baby follows the research data by IOM (Institute of Medicine) 2009: Weight gain during pregnancy: Reexamining the guidelines [14]. Weight gain during pregnancy is based on the BMI (Body Mass Index) before pregnancy. BMI can be calculated from the weight (in kilograms) divided by height squared (Height in meters). Weight gain during pregnancy is based on IOM 2009 as it can be seen in Table I.

TABLE I. WEIGHT GAIN DURING PREGNANCY

BMI before pregnancy	BMI (Kg/m ²)	Weight gain during Pregnancy (Kg)	Weight gain per week during 2-3 trimester (Kg/wk)
Under Weight	< 18.5	12.73-18.18	0.45 (0.45-0.59)
Normal Weight	18.5-24.9	11.36-15.91	0.45 (0.36-0.45)
Over Weight	25.0-29.9	6.82-11.36	0.27 (0.23-0.32)
Obese	>= 30.0	5.00-9.09	0.23 (0.18-0.27)

This table is applied for calculating the appropriated weight for each week and plot line charts of the total appropriated weight during pregnancy. User is also able to plot her own weight to update weight data dynamically as well using Android Plot API [15] as shown in Fig. 3 (A).

D. Daily Calorie Requirement

For daily calorie requirement, user defined data such as days of pregnancy, age, height and weight before pregnant, are used for calorie calculation based on Harris-Benedict Equation [16, 17]. The result is shown in Fig. 3 (B) which is quite similar to Calorie Tracker module of WebMD for iPad [18].

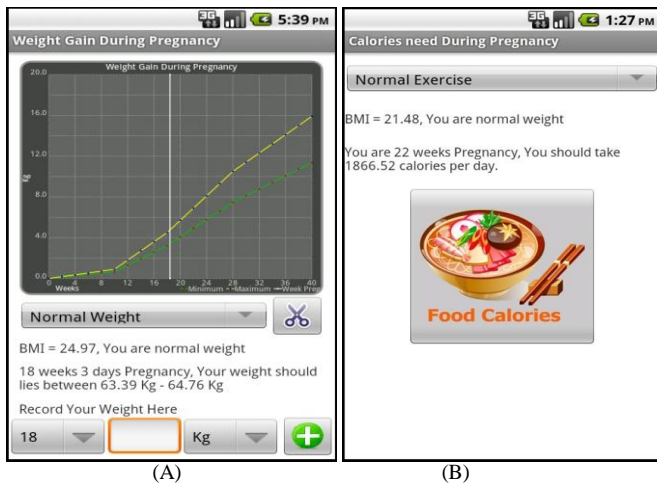


Fig. 3. Weight gain during pregnancy and calorie needs.

E. Miscellaneous

Other functions are also available such recording photos & data by monthly as shown in Fig 4(B), locating mom's position on Google map to find the nearest hospital using GPS as shown in Fig.4(A) or finding specific location on the map with latitude & longitude similar to WebMD Search on Map module of WebMD for iPad [18].

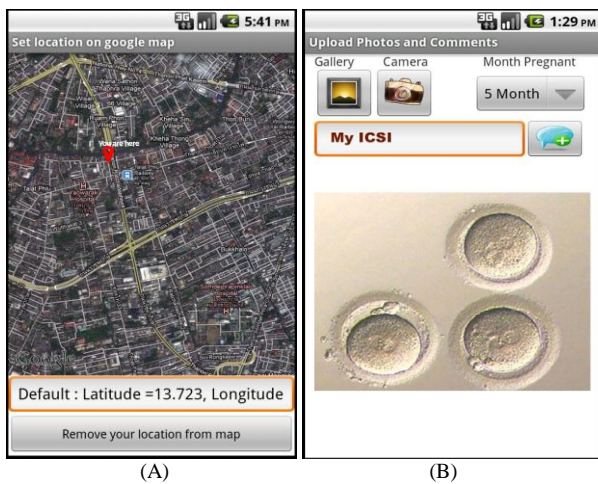


Fig. 4. Other available functions such as: (A) Locating mom's position on Google map to find the nearest hospital. (B) Recording photos & data in monthly basis.

III. ACCURACY TESTING RESULTS

To test accuracy of due date for delivery baby, result from Z-Baby has been compared with the calculation from website BabyCenter [19]. The result shows as in Table II.

TABLE II. COMPARISON OF DUE DATE CALCULATOR FUNCTION BETWEEN BABY CENTER & Z-BABY

1st day of last period	Baby Center		Z-Baby	
	Pregnant week	Due date	Pregnant Week	Due date
Feb 20, 2013	5 Weeks	27 Nov 2013	5 Weeks, 6 Days	27 Nov 2013
Jan 15, 2013	11 Weeks	22 Oct 2013	11 Weeks, 0 Days	22 Oct 2013
Jan 1, 2013	13 Weeks	8 Oct 2013	13 Weeks, 0 Days	8 Oct 2013
Dec 10, 2012	16 Weeks	16 Sep 2013	16 Weeks, 1 Days	16 Sep 2013
Nov 10, 2012	20 Weeks	17 Aug 2013	20 Weeks, 3 Days	17 Aug 2013
Oct 22, 2012	23 Weeks	29 July 2013	23 Weeks, 1 Days	29 July 2013
Oct 2, 2012	26 Weeks	9 July 2013	26 Weeks, 0 Days	9 July 2013
Sep 2, 2012	30 Weeks	9 Jun 2013	30 Weeks, 2 Days	9 Jun 2013
Aug 15, 2012	32 Weeks	22 May 2013	32 Weeks, 6 Days	22 May 2013
July 25, 2012	35 Weeks	1 May 2013	35 Weeks, 6 Days	1 May 2013

For weight gain during pregnancy, Z-Baby has been compared with the website Web Pregnancy Weight Gain Calculator (PWGC) [20] based on the same conditions such as pregnancy week, weight and height. The result shows in Table III, which W is weight before pregnancy (Kg), H is height (cm), Wk and D are pregnancy week period in weeks and days respectively while the BMI indicators such as U is under weight, N is normal and O is overweight.

TABLE III. COMPARISON BETWEEN PWGC AND Z-BABY FOR APPROPRIATED WEIGHT DURING PREGNANCY

W	H	Pregna ncy Week		BMI		Appropriated Weight During Pregnancy (Kg.)	
		wk	d	PWGC	Z-Baby	PWGC	Z-Baby
40	155	10	6	16.7 (U)	16.7 (U)	40.4 - 41.5	41.0 - 41.5
45	162	10	6	17.7 (U)	17.2 (U)	45.4 - 46.5	46.0 - 46.5
48	155	10	6	20.0 (N)	20.0 (N)	48.4 - 49.5	48.9 - 49.3
52	162	10	6	19.8 (N)	19.8 (N)	52.4 - 53.5	52.9 - 53.3
65	155	10	6	27.1 (O)	27.1 (O)	65.4 - 66.5	65.6 - 65.8
80	162	10	6	30.5 (O)	30.5 (O)	80.4 - 81.5	80.6 - 80.8
40	155	18	3	16.7 (U)	16.7 (U)	42.8 - 45.0	43.8 - 45.5
45	162	18	3	17.2 (U)	17.2 (U)	47.8 - 50.0	48.8 - 50.5
48	155	18	3	20.0 (N)	20.0 (N)	50.5 - 52.6	51.4 - 52.8
52	162	18	3	19.8 (N)	19.8 (N)	54.5 - 56.6	55.4 - 56.8

65	155	18	3	27.1 (O)	27.1 (O)	66.7 - 68.7	67.1 - 68.3
80	162	18	3	30.5 (O)	30.5 (O)	81.3 - 83.3	82.1 - 83.3
40	155	30	5	16.7 (U)	16.7 (U)	48.2 - 52.2	49.4 - 53.4
45	162	30	5	17.2 (U)	17.2 (U)	53.2 - 57.2	54.4 - 58.4
48	155	30	5	20.0 (N)	20.0 (N)	55.3 - 58.7	56.3 - 59.7
52	162	30	5	19.8 (N)	19.8 (N)	59.3 - 62.7	60.3 - 63.7
65	155	30	5	27.1 (O)	27.7 (O)	69.5 - 72.9	70.0 - 73.3
80	162	30	5	30.5 (O)	30.5 (O)	83.3 - 86.5	85.0 - 88.3

Calorie required during pregnancy, which calculated by Z-Baby has been compared to the website Calorie Needs and Pregnancy (PCIC) [21]. The result shows as in Table IV which Wk is pregnancy weeks, W is weight (Kg) before pregnancy, H is height (cm). For exercise level column: B is Basal Metabolic Rate, L is Little/no exercise and D is Every day.

TABLE IV. COMPARISON BETWEEN PCIC AND Z-BABY FOR APPROPRIATED CALORIE REQUIREMENT PER DAY

Wk	W	H	Age	Exercise Level		calories/day	
				PCIC	Z-Baby	PCIC	Z-Baby
5	45	154	20	B	Rarely	1362	1493.7
5	45	154	20	L	Normal	1617	1792.2
5	45	154	20	D	Always	2176	2289.5
6	50	157	30	B	Rarely	1368	1495.1
6	50	157	30	L	Normal	1625	1793.8
6	50	157	30	D	Always	2187	2291.8
9	54	162	40	B	Rarely	1369	1485.0
9	54	162	40	L	Normal	1626	1781.2
9	54	162	40	D	Always	2188	2274.9
15	50	155	20	B	Rarely	1611	1601.1
15	50	155	20	L	Normal	1877	1913.9
15	50	155	20	D	Always	2457	2435.2
20	48	159	30	B	Rarely	1553	1522.1
20	48	159	30	L	Normal	1807	1815.2
20	48	159	30	D	Always	2361	2303.6
23	60	163	40	B	Rarely	1628	1603.8
23	60	163	40	L	Normal	1897	1917.3
23	60	163	40	D	Always	2485	2439.7
28	45	160	20	B	Rarely	1763	1693.9
28	45	160	20	L	Normal	2020	1992.3
28	45	160	20	D	Always	2584	2489.8
33	47	157	30	B	Rarely	1730	1660.6
33	47	157	30	L	Normal	1981	1950.8
33	47	157	30	D	Always	2530	2434.4

39	60	155	40	B	Rarely	1804	1753.7
39	60	155	40	L	Normal	2069	2067.1
39	60	155	40	D	Always	2651	2589.4

IV. DISCUSSION & CONCLUSION

To test accuracy of due date for delivery baby, result from Z-Baby has been compared with the calculation from website BabyCenter [19]. Z-Baby shows more details than the BabyCenter. For weight gain during pregnancy, Z-Baby has been compared with the website Web Pregnancy Weight Gain Calculator (PWGC) [20] based on the same conditions such as pregnancy week, weight and height. The result shows that PWGC provides weight range that covers the value calculated from Z-Baby. Calorie required during pregnancy, which calculated by Z-Baby has been compared to the website Calorie Needs and Pregnancy (PCIC) [21]. The result shows similar for the same conditions such as different age, weight, height, age pregnant. However, the calorie per day calculated by Z-Baby is slightly lower than PCIC due to the fact that the Normal exercise level in Z-Baby is equivalent to Little/No exercise by PCIC. Nevertheless, the Paired T-Test value calculated between PCIC and Z-Baby is equal to 0.228837, greater than 0.05 threshold which indicates that the measured values of PCIC and Z-Baby have significant consistency. Therefore, Z-Baby, available for free in Google Play, is accurate for being pregnancy application.

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