Title : Digitization of culinary knowledge in Recipes using Ontologies and applications in the digital kitchen

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Abstract—Digitization of recipes via ontology , demands consideration of humanities, ingredients, methods/techniques bio-active/nutrition components and properties. This paper proposes parsing recipe data for the above information using existing or creating new ontologies for food, chemical composition, genetics and nutrition, and humanities ontologies for contextual data like geography, location, history, population,culinary etiquette,and physical and emotional interaction with fellow diners. Archival and indexing of recipe data are obvious applications of this technology. In addition, digitizing converts the "analog" recipe into a computationally accessible format for sensor-based and programmable kitchen equipment.

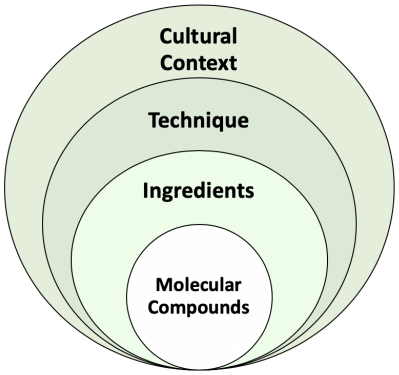
Keywords—Ontology, heritage, humanities, crowd-sourced,recipe structures, human-machine interaction

I. Introduction

Recipes are capsules of knowledge about the use of ingredients and traditions surrounding it. The need for digitisation is two fold; the requirement to preserve generational knowledge of food and to include the knowledge and practice of food in the digital paradigm. Information on recipes both instructions and background is currently static whether in books or online whereas recipe execution always deviates from the static information due to ingredient, equipment or skill level of the individual. Historically these dynamics of recipes are passed orally or through observation from one cook to another and lacks an equivalent written record. The use of sensors and smart software to assist in daily human-tasks and routine is already prevalent for navigation and home assistants like siri/google home/alexa and is extending to smart

refrigerators and ovens. This requires the appropriate tools and infrastructure to organize oral and poorly documented histories for historical and scientific inquiry by both machines and humans, with the objective of extracting insights and patterns relevant to health and humanities. Ontologies are most appropriate to frame the foundational data architecture across the distinct layers of information defined in Figure 1. This enables identifying links between 1. recipes,cuisines and ingredients [1], 2. ingredients and molecular food composition and 3. recipes and foodways (history/culture). In addition to capturing known recipes and food tradition, the proposed framework considers the translation of this knowledge for application on digital kitchen platforms. the same time standardized ontologies ensure future compatibility with emerging ontologies for sensors,

FIGURE 1:



Digitization framework to identify patterns connecting microscopic data to macroscopic trends.

II. Background and Review

A. Recipe Structures

The digitization of recipes is a recent phenomenon considering that people have been cooking for thousands of years and the paradigm of computational systems is accelerating the need for this, besides the urgency to address the loss of food wisdom and knowledge.We present a review of three well known recipe structures, the BBC Food Ontology [2], Schema.org [3] and Google [4]. The next step was to confirm if any online repositories, that have become the default place to find recipes, use any of these structures. Yummly alludes to using schema.org,[5] but no clear evidence of adoption exists, possibly due to the interoperability of such encoding schema. Table 1 above provides a review of fields captured by BBC,Schema and Google;the presence of a field is indicated by the variable name used to define it and the absence of the field is indicated by a “No”. While full explanation of the fields is out of scope, it is worth noting that there are syntactical and semantic differences across these structures.

We have identified a few more fields that contribute to pleasurable cooking as well as a rewarding flavor experience, and they are often seen in well authored cookbooks;

namely presentation/service, environmental conditions when preparing or serving and special emphasis on “Critical Culinary Points” within the instruction set. Service follows preparation and it affects the experience. Whether it be a Plate, Bowl, Platter, Tray, or Cone, factors such as the thickness of a sauce, size/shape of pieces, region of origin will influence the choice of vessels and cutlery, as well as circumstances of eating in or taking out. The climate of the cooking environment can have dramatic impact on the recipes’ final flavor, a bowl of noodles assembled in December with room temperature ingredients in Malaysia would much warmer that of one with the same ingredients in Denmark hence the inclusion of intended conditions will ensure greater success. Textures of foods at point of consumption are impacted by the temperature - the same custard recipe served cool or warm could be thin or gloppy.

Recipes on blogs often accompany personal narratives which indicate Critical Culinary Points, such as; Mom may have told you to not make meringue after it rains yet if you did not get this advice when you learned the recipe you might go ahead and fail. The reason being the sugar which makes the recipe vulnerable to humidity.

B. Ingredient Ontologies

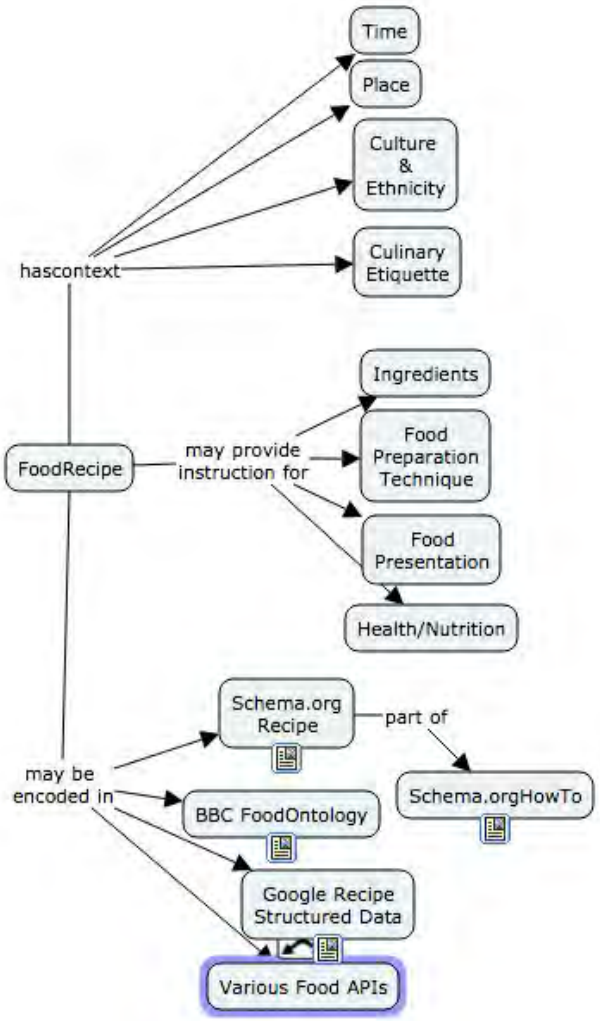
Primary among computational applications for recipes is the capability for ingredient substitutions; for reasons of health, availability, allergy or taste. Hence when a recipe ontology or any structured representation links to an ingredient ontology, it must be queryable for such criteria.

TABLE 1: Comparison of Recipe Structures

Field Grouping	Common Recipe Field Names	Google	Schema.org	BBC
Creator Metadata	Recipe Name	Name	Name	Food
Creator Metadata	Servings, Yield	recipeYield	recipeYield	Serves
Creator Metadata	Author, Creator	Author	Author	No
Creator Metadata	Date	datePublished	datePublished	No
Creator Metadata	Description	Description	Description	No
Creator Metadata	Review	review	review	No
Creator Metadata	Tags, Keywords	Keywords	Keywords	No
Creator Metadata	Rating	AggregateRating	AggregateRating	No
Cultural Context	Collection, Category, Album	recipeCategory	recipeCategory	Collection
Cultural Context	Course	No	No	Course
Cultural Context	Cuisine	recipeCuisine	recipeCuisine	Cuisine
Cultural Context	Menu	No	No	Menu
Cultural Context	Occasion, Event	No	No	Occasion
Cultural Context	Restricted Diet	No	SuitableForDiet	Diet
Cultural Context	Seasonality	No	No	Season
Ingredients	Ingredient	recipeIngredient	recipeIngredient	Ingredients
Ingredients	Ingredient List	recipeIngredient	No	Ingredient List
Ingredients	Shopping Tip	No	No	ShoppingCategory
Food Preparation Technique	Total Time	TotalTime	TotalTime	No
Food Preparation Technique	Cooking TIme	cooktime	cooktime	No
Food Preparation Technique	Equipment, Tool, Utensil	No	tool	No
Food Preparation Technique	Instructions, Method, Directions	recipeInstructions	cookingMethod	Method
Food Preparation Technique	Perform Time	No	performTime	No
Food Preparation Technique	Preparation Time	prepTime	prepTime	No
Food Preparation Technique	Step, Stage, Phase	recipeInstruction	recipeInstruction	Step
Food Preparation Technique	Technique	No	No	Technique
Media-All Data Sets	Audio Clip, Audio Note, Sound Byte,	No	Audio	No
Media-All Data Sets	Photo	Image	Image	No
Media-All Data Sets	Video	Video	Video	No
Nutritional Content	Calories	nutrition.calories	calories	No
Nutritional Content	Nutritional Information	No	nutrition	No

FoodON [6] covers raw ingredients, food products and product types specifically intended to address semantic applications in food safety, food processing and agricultural and animal husbandry practices. It can be queried for classification information such as animal/plant based and which anatomical part of the plant or animal, processing/production method such as canned/farmed and geographical region such as continent or country. FoodOn covers both raw and processed foods. FOODS [7] lists the ingredients in a prepared dish and gives the nutritional properties namely the vitamins, minerals and salts in a given ingredient. Food product ontology [8] modeled on GoodRelations [9] classifies food in categories like egg, fish, meat, dairy, bakery, fruit,vegetable, spices, beverages.. Etc and provides nutrition information much like that on a product label. The Food Phenotype Ontology (work in progress) describes the chemical composition of a food, and its properties including flavor and maybe applied to ascribe flavor descriptors to a recipe based on its ingredients.[10]. There are a number of structured food databases such as gbif.org, dfc.chemnetbase.com which if annotated against these Food Ontologies are valuable information.

The basic Recipe ontology in figure 2 describes instantiation of terms from recipe schemas reviewed in Section II A, and covers the additional contextual aspects.



III. Crowd-sourcing

Food is inherently a social activity, and in the digital era, people enjoy sharing food experiences of different kinds on social media sites like photos on instagram, rating food on sites like Yelp.com as well recipe blogging or contributing to community sites like allrecipes . Ubiquitous access to mobile smartphones and tablets proliferates such

crowdsourced content which is especially rich in subjective individual perspectives reflecting various cultural and societal influences. The value of "non-authoritative" information contribution is clear from UNESCO projects that do not rely solely on the traditional GLAMS (galleries, libraries, archives and museums) experts, but include local people into their policies and smartphones provide scalability to these efforts. (Han et al. 2014b).Prior to digital media recipes were often published in popular media like newspapers and home magazines. A study of recipes in historical Dutch newspapers from 1945-1995 explains the process of information parsing and mining for patterns in human and overall societal behavior.[11] Other studies [12][13] have explored the connection between culture and ingredients and the work by [12], states the significance of these findings towards personalising food.

Since the value of knowledge discovery in user content is valid, an application with the explicit aim to crowd-sourcing must have a interface that is compatible to humanistic ways of thinking and functioning. Figure 3 represents a core-and-context narrative of a recipe. The constituents at the core are ingredients,instructions, and manner of serving. The outer circle represents the formative influences that created a recipe and will likely create re-inventions. This heritage also creates strong association to a land and the people. A recipe is only complete with both the core elements and its rich context. In using mobile device app technology, information about the time, location and weather can be automatically captured. With the reference to the Meringue example in II, this information is relevant to the success of the recipe.

FIGURE 3: Crowd sourcing principles.

Recipe narration by humans follows a context-to-core format. [14]

IV. Conclusion

Crowd-sourcing of food knowledge includes all citizens the world over in contributing towards its preservation. This requires an interoperable infrastructure of ontologies, and user interfaces designed on methodologies of ethnography, anthropology, and psychology for contributors to record and share their unique stories through recipes. Traditional food wisdom is of value in innovation by revealing forgotten information or providing time-tested data on diet-health correlations. In addition this project has potential to introduce sub-cultures around the world with implications for informed marketing and culinary tourism.

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