Chapter 6
Odor Recorder

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ABSTRACT
An odor recorder is a gadget to record smells as well as reproduce them. The odor recorder to record the recipe of multiple-component odor, the dynamical change of the odor recipe even under the environmental change, such as humidity and temperature, has been so far studied. The methods to solve the mixture quantification problem, such as multiple linear regression, partial least squares, neural network, etc., are described. Furthermore, the active odor sensing system, which explores the recipe of the blended odor with its output pattern’s similarity to that of the target odor, is described. Then, an example of the actual implementation of the odor recorder based upon a QCM sensor array is shown. Based upon that odor recorder, the experimental result of the fruit flavors made up of 4-8 odor components is described. Then a mass spectrometer without GC for determining the recipe of a few dozen odor components is explained. The mass spectrometry is useful to overcome the collinearity problem. However, the accuracy of the recipe estimation is insufficient when the number of odor-component candidates is more than a few hundred. The selection methods of odor components among the huge number of candidates and its application to the fruit flavors are explained. Finally, the method to find an appropriate set of odor components and the simulation result using mass spectrum database are described.

INTRODUCTION
Vision and audition among five senses can be nowadays easily recorded and reproduced under multi-media environment. Since the fields of vision and audition have been so far mature, it is indispensable to open the new field in addition to those senses. The study of recording olfactory information is very challenging.

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Although odors have been analyzed using GC/MS (Gas Chromatography/Mass Spectrometry) for long time, odor-sensing systems often called electronic noses have been studied for last two decades (Pearce, Schiffman, Nagle, & Gardner, 2003). The odor sensing system offers simple, rapid, and objective evaluation method in place of GC/MS. Its principle is based upon the pattern recognition of the outputs of the multiple sensors with partially overlapping specificities in
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the same manner as that of a biological olfactory system. The group of UK proposed that principle first (Persaud & Godd, 1982), the concept of the similarity was introduced by Japanese group (Kaneyasu, Ikegami, Arima, & Iwanaga, 1987), and then a combination of a sensor array with neural network was proposed (Nakamoto & Morizumi, 1988). Thereafter, many researchers came into this field and the research on the odor sensing system became popular (Nagle, Schiffman, & Gutierrez-Osuna, 1998; Gardner & Bartlett, 1994). Nowadays the international symposium on olfaction and electronic noses is held every two years.

On the other hand, an olfactory display, a device for smell presentation, was recently studied in virtual reality (Kaye, 2004). A computer-controlled scent diffuser connected to Internet (Messager, 2002), an odor-source localization in virtual space (Hirose, 2002) and the olfactory display for delivering smell to a single user’s nose were studied (Yanagida, Kawato, Noma, Tomono, & Tetsutani, 2004).

An odor recorder with the capability of reproducing smells as well as recording them in the same manner as that realized in VCR (Video Cassette Recorder) was proposed (Nakamoto, Nakahira, Hiramatsu, & Morizumi, 2001). This is the new field since the odor sensing system and the olfactory display have been independently studied. There are many consumer products related to smell such as food, beverage, cosmetics, toothpaste, air fresheners for breath, room, and bathroom, etc. It is possible to apply the odor recorder to a variety of fields such as e-commerce, game, virtual reality, cinema, etc.

Moreover, the odor recorder can be used for the research on cultural anthropology of the senses. The olfactory information about historically and ethnologically important objects can be preserved and be reproduced. Objects with scents around the world such as Asian, African, Caribbean, and European areas can be recorded. Especially, cooking is strongly related to scents. A variety of foods and beverages around the world accompanied with scents can be reproduced using the odor recorder.

In the odor recorder, the odor quality is represented as the recipe of the multiple odor components. It is feasible to express a variety of odors by blending multiple ingredients. The recipe can be determined so that the similarity of the blended odor to the original one can be maximized. Thus, the mixture quantification technique is indispensable although the classification is focused on in most of odor sensing system. The mixture quantification technique is described in the next section.

There are two types of odor recorder. One determines the odor recipe kept constant during recording. The other is the odor recorder for obtaining the recipe of dynamically changing the odor. These two types of the odor recorder are reviewed here.

When we quantify odors composed of many components, mass spectrometry is useful. However, the selection of odor components among huge number of candidates is necessary to perform the quantification. This technique is also described.

One of the fundamental issues is to determine an appropriate set of odor components. You can think about the aspect from the physiology of olfaction. Buck and Axel reported the multigene family of G-protein coupled ORs (Olfactory Receptors) in 1991, and then molecular biology of olfaction rapidly progressed (Buck & Axel, 1991). They won the Nobel Prize in Physiology or Medicine in 2004. However, primary smells have not been so far discovered unlike primary colors in vision although the stereochemical theory was proposed by Amoore (1970).

Unlike the primary colors in the vision, however, the combination of several odor components does not cover whole range of the smell. Thus, the technique to select odor components so that the range of the smell can be maximized is described in the latter part of this chapter.